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REPORT ON WATER QUALITY MANAGEMENT OF THE LAKE TROUT WATERS OF SOUTHEASTERN ONTARIO

VOLUME II

February 1980

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Ministry of the Environment

Ontario Ministry of Natural Resources

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Ministry
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Environment

133 Dalton Street, Box 820, Kingston, Ontario K7L 4X6
Tel: 549-4000

April 17th, 1980

M. Griffiths
Water Resources Branch
1 St. Clair Avenue West
TORONTO, Ontario
M4V 1K6

Dear Mrs. Griffiths:

Provided herewith for your information is a copy of a joint Ministry of the Environment/Ministry of Natural Resources publication entitled "Report on Water Quality Management of the Lake Trout Waters of Southeastern Ontario - Volume II -1980".

The report is based on three years of water quality studies and provides a documentation of the water quality condition of 52 lake trout waters located within the Counties of Renfrew, Hastings, Lennox and Addington, Frontenac and Nipissing District. Based on an assessment of the sensitivity of these lakes to water quality change as a result of further nutrient inputs, the lakes have been grouped into three categories of sensitivities. Recommendations are provided for each grouping which reflect the level of concern and controls considered necessary to minimize and/or prevent further nutrient inputs to the lakes.

If you require additional copies of the report or wish to obtain clarification about the contents of the report, please feel free to contact the Technical Support Section, Ministry of the Environment at 133 Dalton Street, Kingston, K7L 4X6.

Yours truly,

R.E. Moore,
Regional Director,
Southeastern Region,
Ministry of the Environment.

K.K. Irizawa,
Regional Director,
Algonquin Region,
Ministry of Natural Resources.

MJG/ck

Ref. 72917

REPORT

ON

WATER QUALITY MANAGEMENT

OF THE

LAKE TROUT WATERS

OF

SOUTHEASTERN ONTARIO

VOLUME II

FEBRUARY, 1980

Prepared by:

Technical Support Section
Southeastern Region
Ontario Ministry of the Environment

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SUMMARY

The Southeastern Region of the Ministry of the Environment in conjunction with the Ministry of Natural Resources initiated in 1975, a Lake Survey Program. The Program was designed to document existing water quality conditions in the lakes selected for study and to assist land use planners and resource managers in assessing the potential water quality implications of future shoreline development proposals. The relatively few lakes in Southeastern Ontario which have adequate oxygen conditions to permit deep water fauna, such as lake trout, to survive are of primary concern. Elimination of the oxygen resource of these lakes is a potential implication of further nutrient inputs associated with shoreline development.

In October, 1977, a joint MOE/MNR publication entitled "Report On Water Quality Management of the Lake Trout Waters of Southeastern Ontario" was released. The 1977 report dealt with 52 lake trout waters located in the southern portion of Environment's Southeastern Region. This, the second report of findings of the Lakes Survey Program, deals with a further 52 lake trout waters located primarily in the northern portion of Environment's Southeastern Region. These 52 lakes either currently support populations of lake trout or contain water quality conditions which appear to be suitable for survival of lake trout.

Similar to the first publication, this report has been written by the Ministry of the Environment. It is being released as a joint MOE/MNR publication in order to signify that water quality is a matter of mutual interest and concern and also to indicate that the contents of the report are endorsed by both Ministries. It should be noted however, that the concerns of the Ministry of Natural Resources are not confined to water quality factors. For this reason the comments which the Ministry of Natural Resources might make on any specific shoreline development proposed will be guided by but not necessarily limited to the contents of this report.

Based on both quantitative and empirical assessment techniques, the report groups the 52 lakes into three categories of differing sensitivities to possible oxygen depletion as a result of further nutrient inputs. Each of the three categories of lakes are accompanied by a set of recommendations pertaining to shoreline development. The recommendations are intended to be interim in nature and will be reviewed and revised as necessary on or before December 31, 1984.

It should be noted that the acceptable level of shoreline development on any given lake and the ability of a lake to sustain a viable lake trout fishery involve numerous factors. Water quality is only one of these factors and is the only aspect dealt with in this report.

For ease of reference, the lakes dealt with in this report are listed below in alphabetical order along with the appropriate Appendix page numbers on which a summary of the lake's water quality conditions can be found.

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INTRODUCTION

During 1976, 1977 and 1978, the Southeastern Region of the Ministry of the Environment, with assistance of the Ministry of Natural Resources and Loyalist College (Belleville) completed water quality studies on fifty-two lake trout waters located in North Hastings, Lennox and Addington, Renfrew and Frontenac Counties.

These studies were a continuation of the MOE Southeastern Region's Lake Survey Program initiated in 1975. The Program was designed primarily to assist land use planners and resource managers in assessing the potential water quality implications of further shoreline development. The information obtained also provides a valuable documentation of the quality of the lake trout habitat and will therefore assist the Ministry of Natural Resources in developing and/or re-assessing fisheries management strategies.

Concurrent with the Southeastern Region's Lake Survey Program, a research project involving the Ministries of Housing, Environment and Natural Resources has been in progress. The research project entitled "Lakeshore Capacity Study" involves a careful examination of water quality, fisheries and wildlife, and sociological factors in an attempt to define the appropriate assessment techniques and criteria for determining a lake's shoreline development capacity.

Recognizing that the results of the Lakeshore Capacity Study could modify some of the conclusions drawn from the Southeastern Region's Lake Survey Program, this report provides only a preliminary assessment of the survey findings. A set of provisional or interim water quality management recommendations are outlined and are intended to ensure maintenance of the existing water quality conditions within each lake.

The interim water quality management recommendations are intended to serve for a period of time not later than December 31, 1984. By that date, the Lakeshore Capacity Study will have been completed and the MOE Southeastern Region will be prepared to propose for the consideration of the appropriate Municipalities and Planning Boards a long term water quality management strategy for the lakes studied.

WATER QUALITY REQUIREMENTS FOR LAKE TROUT AND RECREATIONAL USE

Water Quality Requirements for Lake Trout

Scott and Crossman (1) have provided an excellent summary of the biology of the lake trout species and Martin and Olver (2) have described in detail, the characteristics of Ontario lake trout lakes. Both of these publications are suggested reading for a more detailed understanding of the factors which influence the suitability of a body of water as habitat for lake trout. Factors in addition to water quality which influence the ability of a lake to support a lake trout fishery include water level fluctuations, stocking rates, harvesting pressure and introductions of other fish species. This report deals only with water quality factors.

The two most significant impacts which human activities have had on water quality conditions of lake trout waters in Ontario are acidification and nutrient enrichment. Critical increases in the acidity of lakes in the Sudbury vicinity have been well documented. Some of the lakes discussed in this report, because of their low alkalinity and poor buffering capacity, might be more sensitive to the stresses of acidification than to nutrient enrichment effects. A third human influence which has possibly had some impact on water quality conditions in the Southeastern Ontario lakes is that of regulated water levels. This report will deal only with potential effects of additional nutrient enrichment resulting from further shoreline development.

Relative to habitat requirements of the lake trout species, a critical potential effect of nutrient enrichment is one of oxygen depletion. Since temperature is also a limiting factor for lake trout, dissolved oxygen and temperature conditions must be considered together.

The literature suggests that lake trout are capable of withstanding short term exposure to water temperatures as high as 15°C and oxygen levels as low as 4 mg/L. Prolonged exposure to these conditions would constitute stress and a threat to the continued survival of the population. The preferred or optimal upper temperature and lower oxygen levels are considered to be in the range of 10 to 12°C and 5 to 6 mg/L respectively. For the purpose of this report the assessment of water quality is based on optimal conditions for long term survival.

While this report will not be considering the water quality requirements of the other forms of aquatic life which exist in a lake trout lake, it should be noted that some of these organisms are essential as food items for lake trout and therefore must also be protected.

Water Quality Requirements for Recreational Use

Factors which relate to water quality requirements for recreational use are water clarity (measured with a Secchi disc) and algal densities (determined as chlorophyll concentrations). Lakes with a mean summer Secchi disc visibility depth exceeding 5.0 metres (16.4 feet) have relatively little phytoplankton in their water column and hence have very little biological enrichment. These lakes are generally considered to be oligotrophic. Oligotrophic lakes have a low rate of nutrient supply relative to their volume and are almost invariably deep large basins. Secchi disc readings between 3.0 metres (9.8 feet) and 5.0 metres (16.4 feet) typify most of the lakes in Southeastern Ontario. These

lakes are termed mesotrophic and are generally mid-sized basins with maximum depths under 15.0 metres (49.2 feet) Lakes with Secchi disc readings less than 3.0 metres (9.8 feet) are normally considered to be eutrophic and exhibit a reduction of light transmission due in part to a high concentration of algae suspended in their waters. These lakes are often shallow and have a high rate of nutrient supply in relation to their volume.

Lakes with mean chlorophyll concentrations between 0 and 2 ug/L indicate low algal densities and very little biological productivity. Concentrations between 2 and 5 ug/L characterize most of the recreational lakes in Southeastern Ontario and although moderately high, may be considered acceptable for most water oriented activities. Levels exceeding 5 ug/L, on a seasonal average, reflect high algal densities. At these higher densities, nuisance accumulations of algae may occur occasionally and detract from the aesthetic appeal of the water and interfere with lake related recreation such as swimming and water skiing.

NUTRIENT ENRICHMENT EFFECTS

In order to understand the basis or rationale utilized to arrive at the recommendations contained in this report, it is necessary to understand in general terms some of the natural processes which occur within a lake trout lake and the means by which nutrient enrichment can affect dissolved oxygen conditions.

With the exception of lakes which have regulated water levels and experience drawdown during the summer and early fall, the temperature regime of lake trout waters is determined by natural processes. For the most part, the lakes included

in this study have the 10°C temperature level established at depths of 7.6 to 10.7 metres (25 to 35 feet) below the surface of the lake by mid-summer. Therefore based on the temperature requirements of the species, the top 9.1 metres (30 feet) or so of the lake trout waters in Southeastern Ontario would be unsuitable for lake trout between mid-summer and early fall.

The oxygen supply in lake trout waters normally is replenished twice a year through a natural lake process termed spring and fall overturn. On these two occasions, the water temperature becomes uniform from surface to bottom and the entire water column is freed to overturn or undergo mixing when subjected to wind forces. This natural process permits oxygen to be distributed throughout the entire volume of the lake. This mixing process lasts only a short period of time until the lake's water column commences to develop a temperature gradient or becomes thermally stratified or freezes over. During the summer stratification period, the bottom waters of a lake become isolated by means of a thermal barrier from the lake's surface waters. While the surface waters are in a state of constant mixing throughout the summer and therefore remain well aerated or supplied with oxygen, the bottom waters of the lake are limited in their ability to renew their oxygen supplies and with some exceptions to be mentioned later, must rely on the initial supply of oxygen obtained during spring overturn to support respiration and decomposition during the summer stratification period. The most significant demand on the oxygen resource of a lake is associated with the process of decomposing the organic matter which the lake produces. In many lakes which exhibit thermal stratification between spring and fall overturn the decomposition of organic matter utilizes the total oxygen supply of the bottom waters of the lake. This is a natural phenomenon and is not confined to lakes which support shoreline development. It is not unusual nor unexpected to discover severe oxygen depletion in the bottom waters of totally undeveloped lakes. A number of examples of undeveloped lakes with conditions of severe oxygen depletion were described in a previous MOE/MNR report (3).

In addition to the natural condition of lakes it is recognized that cultural enrichment resulting from human activities within a lake's drainage basin can influence a lake's water quality conditions.

Aquatic plants, like their terrestrial counterparts, convert nutrients, carbon dioxide and sunlight into plant tissue (i.e. organic matter). The amount of organic matter produced on land or in water is frequently controlled or limited by the nutrient which is in the shortest supply. In lakes, phosphorus is the nutrient which normally is least available and therefore the nutrient which determines the amount of organic matter produced in the lake's surface waters. In lake trout lakes most of the phosphorus supply is converted into tiny microscopic plants called algae. The rate of production of algae controls the rate of biological production at all levels of the food chain up to and including fish. The biomass or quantity of algae in water can be readily measured in a laboratory by means of chemical analysis of the chlorophyll content of a water sample. While several chlorophyll pigments occur in plant tissue, the predominant pigment is chlorophyll "a". All use of the term chlorophyll in this report refers to the chlorophyll "a" pigment only.

In addition to controlling the rate of biological production through a lake's food chain the organic matter produced in the surface water of a lake eventually decomposes and in the process utilizes oxygen. Therefore in order to assess the potential water quality implications of additional nutrient inputs to a lake trout lake the relationship between the phosphorus supply, algal production and oxygen demand must be examined. A more detailed discussion of the above-mentioned relationship follows.

NUTRIENT SENSITIVITIES

Algal Production

Since phosphorus is the nutrient least available to plants, it is the phosphorus concentration in the surface water of a lake which will determine the lake's trophic status or level of plant production. The relationship between phosphorus concentration and chlorophyll has been described in detail by Dillon and Rigler (4).

The phosphorus concentration present in any given lake is a function of the quantity of phosphorus being supplied to the lake as well as the lake's physical features (i.e. surface area, volume, flushing rate). One can readily visualize that a bag of fertilizer dumped into a small pond and completely mixed with the water would increase the nutrient concentration enough to stimulate increased plant production whereas the same bag of fertilizer completely mixed into Lake Superior would have an undetectable effect on the lake's nutrient concentration and level of plant production.

Similarly, since the fifty-two lakes considered in this report vary in size from 22 hectares to 3798 hectares (54 to 9,386 acres) of surface area; it is expected that a variation in phosphorus concentration and plant growth would occur in response to identical increases in phosphorus supplies. The nutrient input resulting from an additional 100 cottages on Jeffery Lake with a surface area of 42 hectares (104 acres) would be expected to have a greater effect on plant production than the same 100 cottages located on Bark Lake with a surface area of 3798 hectares (9,386 acres). The difference in response being simply available dilution.

Based on the work of Dillon and Rigler (4) one can quantify the above-mentioned relationship by means of a mathematical formula. The result is a "sensitivity index" which expresses the sensitivity of a lake to increased phosphorus supply in relative numerical terms. The index can be utilized to quantify and rank for comparison purposes the expected response of a group of lakes to a unit increase in phosphorus supply. The formula for the "sensitivity index" is provided in Appendix B along with working examples.

Table 1 provides the calculated "sensitivity index" for each of the fifty-two lakes considered in this report. The lakes are listed in order of sensitivity from highest to lowest and in this order would be expected to exhibit the greatest to least increase in plant production per unit increase in phosphorus supply.

Dissolved Oxygen Depletion

The oxygen reserve in the deep waters of a lake trout lake at the end of the summer stratification period is a function of the lake's level of plant production modified by the lake's physical characteristics. While no suitable model has been developed which will permit one to quantify the sensitivity of a lake's oxygen resource to depletion, it is possible to identify the various factors involved and therefore make a qualitative assessment of a lake's relative sensitivity to oxygen depletion. For the fifty-two lake trout waters discussed in this report, the following factors can be recognized as having an influence on the lake's oxygen resource and usable trout habitat.

Table 1. Sensitivity Index for Fifty-two Lake Trout Waters Showing Relative Potential for Increased Algal Production Per Unit Increase in Phosphorus Supply

Lake	Surface Area hectares (acres)	Flushing Rate (times/year)	Sensitivity Index ($\times 10^{-5}$)
Limestone (Brougham)	22 (54)	0.3	1088
Wabun	44 (110)	0.1	460
Jeffery	42 (104)	0.2	451
Little Salmon	38 (94)	0.3	446
Limestone (Mayo)	45 (112)	0.2	419
Little Clear	55 (136)	0.1	343
Jamieson	48 (119)	0.7	295
Green	75 (185)	0.1	219
Big Mink - North	80 (198)	0.2	197
Colton	62 (154)	0.7	185
Bay	87 (215)	0.3	159
McMaster	102 (252)	0.3	134
Diamond (Radcliffe)	81 (200)	0.5	127
Charlotte	116 (287)	0.2	111
Lavalee	85 (210)	0.8	96
Raglan	137 (338)	0.2	88
Faraday	113 (279)	0.6	85
Purdy	133 (328)	0.1	85
Burns	143 (354)	0.1	83
Norway	271 (670)	0.2	80
Big Salmon	148 (366)	0.2	77
Cashel	168 (415)	0.3	64
Big Clear	187 (463)	0.1	59
Kulas (Greenan)	90 (222)	2.3	56
Trout (Len)	158 (390)	0.4	56
Mayo	183 (452)	0.4	51
Diamond (Herschel)	150 (371)	0.9	50
Cross (Lyell)	202 (500)	0.2	48
Trout (Stubbs)	137 (339)	0.7	46
L'Amable	179 (443)	0.4	39
McCauley	121 (300)	2.9	36
Mephisto	150 (373	0.9	31
Carson	273 (675)	0.3	30
Wadsworth	199 (492)	1.2	30
St. Peter	235 (580)	1.3	22
Otter (Cotter)	229 (566)	1.3	21
Halfway - East	62 (152)	7.4	17
McKenzie	312 (770)	0.8	17
Halfway - West	96 (237)	7.0	15
Wollaston	368 (910)	1.2	10
Lower Hay	449 (1109)	1.3	8
Papineau	781 (1930)	0.3	7
Paugh	712 (1760)	0.2	7
Limerick	745 (1840)	1.0	5
Kamaniskeg - North	924 (2284)	0.3	5
Clear	1730 (4275)	0.2	2
Weslemkoon	1956 (4833)	0.4	2
Muskrat	1201 (2969)	0.8	2
Aylen	2015 (4980)	0.1	2
Round	3074 (7596)	0.8	0.5
Kamaniskeg - South	1295 (3200)	5.9	0.2
Bark	3798 (9386)	0.3	0.2

A. Mean Depth of Lake

Since plant matter produced in the surface waters of a lake trout lake is for the most part decomposed in the bottom waters of the lake, it would be reasonable to hypothesize that the ratio of water volume producing plant tissue to the water volume decomposing plant tissue would have a significant influence on the extent of oxygen depletion which occurs. The rationale supporting this hypothesis is developed through the following examples.

The quantity of plant matter (biomass) produced as algae is the function of algal density times the volume of water in which algal growth is occurring. One therefore can visualize that in two lakes with identical algal densities (i.e. chlorophyll levels) the lake with the largest surface area will be producing the most pounds of plant matter to be decomposed. For example, two of the study lakes, Paugh and McMaster which have comparable algal densities (1.0 and 1.1 micrograms per litre respectively), comparable depths of light penetration or photosynthetic activity 11 and 10 metres (36 and 34 feet) respectively, but different surface areas 713 and 104 hectares (1,762 and 253 acres) respectively, would obviously be producing different quantities (i.e. total kilograms) of algae. Paugh Lake with the largest surface area would be producing the largest biomass of algae and one might on this basis project that its oxygen resource would be more seriously depleted than that of McMaster Lake. Reference to Pages A72 and A84 of Appendix A will however reveal that this latter assumption is incorrect. McMaster Lake experiences more serious oxygen depletion than Paugh Lake.

Carrying the comparison between Paugh Lake and McMaster Lake a step further, both lakes achieved complete mixing during spring overturn and therefore commenced the period of summer stratification with uniform and saturated oxygen conditions from the surface to the bottom. Paugh Lake however is a much deeper lake than McMaster. Paugh Lake has a maximum depth of 51.8 metres (170 feet) and a mean depth of 13.8 metres (45.3 feet) whereas the maximum depth of McMaster Lake is 21 metres (69 feet) and its mean depth is 7.8 metres (25.6 feet). The logical conclusion from this comparison is that deep lakes, because of their large volume of bottom water, have a greater oxygen reserve than shallower lakes. They are therefore provided with a greater capacity to decompose organic matter and maintain suitable lake trout habitat than shallower lakes.

Table 2 provides a listing of the fifty-two study lakes ranked in order of mean depth. Corresponding chlorophyll levels and descriptions of oxygen conditions are also provided. The relationship between mean depth and oxygen condition is readily apparent however it is also evident that additional factors have an influence on a lake's oxygen condition and/or usable trout habitat.

B. Spring Overturn

While most lakes in Ontario undergo spring and fall overturn which serves to replenish the oxygen resource of the deep waters, not all lakes overturn and for those which do the degree and extent of overturn varies considerably.

Table 2. Relationship Between Mean Depth and Lake Oxygen Conditions

Lake	Surface Area hectares (acres)	Flushing Rate (times/yr)	Chlorophyll ug/L	Mean Depth metre(ft)	Oxygen * Condition
Aylen	2014 (4978)	0.1	1.2	27.1 (89.1)	Excellent
Bark	3798 (9386)	0.3	1.0	24.3 (79.6)	Excellent
Big Clear	187 (463)	0.1	1.3	20.1 (66.0)	Excellent
L'Amable	179 (443)	0.4	0.7	19.6 (64.3)	Excellent
Papineau	781 (1930)	0.1	0.8	18.3 (60.0)	Excellent
Muskrat	1202 (2969)	0.8	7.0	17.7 (58.2)	Poor
Little Clear	55 (136)	0.1	1.3	17.5 (57.5)	Good
Green	75 (185)	0.1	0.8	16.8 (55.0)	Good
Little Salmon	38 (94)	0.3	1.3	16.7 (54.7)	Good
Mephisto	151 (373)	0.9	0.8	16.2 (53.2)	Excellent
Trout	137 (339)	0.7	1.4	15.4 (50.5)	Excellent
Trout (Len)	157 (390)	0.4	1.3	14.5 (47.5)	Poor
Paugh	712 (1760)	0.2	1.0	14.1 (46.3)	Excellent
Diamond (Radcliffe)	81 (200)	0.5	1.2	13.8 (45.3)	Excellent
Kamaniskeg S.	1295 (3200)	5.9	1.2	13.4 (43.8)	Excellent
Lavallee	85 (210)	0.8	1.1	13.3 (43.6)	Excellent
Wabun	45 (110)	0.8	1.4	13.3 (43.6)	Fair
Big Salmon	148 (366)	0.2	1.7	13.3 (43.6)	Excellent
Round	3074 (7596)	0.8	1.7	13.2 (43.2)	Excellent
Limestone(Mayo)	45 (112)	0.2	1.0	12.6 (41.2)	Poor
Jeffery	42 (104)	0.2	0.8	12.5 (41.0)	Good
Carson	273 (675)	0.3	1.1	12.3 (40.4)	Excellent
Halfway-East	62 (152)	7.4	1.0	11.8 (38.6)	Fair
Burns	143 (354)	0.1	1.3	11.3 (37.1)	Good
Clear	1730 (4275)	0.2	1.9	11.2 (36.7	Poor
Limestone (Brougham)	22 (54)	0.3	1.8	11.1 (36.3)	Poor
Lyell	202 (500)	0.2	2.1	10.6 (34.8)	Excellent
Bay	87 (215)	0.3	0.7	10.3 (33.8)	Good
Colton	62 (154)	0.7	1.4	9.7 (31.8)	Good
Norway	271 (370)	0.2	1.5	9.4 (30.8)	Poor
Wollaston	386 (910)	1.2	1.2	9.4 (30.8)	Fair
Lower Hay	448 (1108)	1.3	2.3	9.3 (30.5)	Excellent
Weslemkoon	1956 (4833)	0.4	1.4	9.3 (30.5)	Excellent
Raglan	137 (338)	0.2	2.1	9.2 (30.3)	Poor
McKenzie	312 (770)	0.8	2.1	9.0 (29.5)	Excellent
Purdy	133 (328)	0.1	0.7	9.0 (29.5)	Fair
Faraday	113 (280)	0.6	1.4	9.0 (29.5)	Poor
Kamaniskeg N.	924 (2284)	0.3	1.5	8.8 (29.0)	Poor
Otter	229 (566)	1.3	1.3	8.6 (28.3)	Excellent
Jamieson	48 (119)	0.7	0.9	8.5 (27.9)	Poor
Halfway - West	96 (237)	7.0	1.0	8.5 (27.9)	Fair
Big Mink	80 (197)	0.2	2.3	8.5 (27.9)	Excellent
Limerick	745 (1840)	1.0	0.8	8.4 (27.6)	Poor
Diamond (Herschel)	150 (371)	0.9	1.1	8.3 (27.2)	Poor
Kulas (Greenan)	90 (222)	2.3	1.5	8.1 (26.5)	Poor
Cashel	168 (415)	0.3	1.2	7.8 (25.6)	Poor
McMaster	102 (252)	0.3	1.1	7.8 (25.6)	Poor
St. Peter	235 (580)	1.3	1.1	7.6 (24.9)	Good
Mayo	183 (452)	0.4	0.8	7.6 (24.9)	Poor
Charlotte	116 (287)	0.2	1.4	7.4 (24.3)	Poor
Wadsworth	199 (492)	1.2	2.0	7.2 (23.6)	Good
McCauley	121 (300)	2.9	2.1	6.6 (21.6)	Good

* Excellent - greater than 12 metres (40 ft) of suitable lake trout habitat
Good - between 6 - 12 metres (20 - 40 ft) of suitable lake trout habitat
Fair - between 3 - 6 metres (10 - 20 ft.) of suitable lake trout habitat
Poor - less than 3 metres (10 ft) of suitable lake trout habitat

Table 3 provides oxygen and temperature data for each of the fifty-two lakes. These data are for the bottom of the lake on the sampling date closest to the time of spring overturn. It can be noted that some lakes such as McMaster and Paugh had experienced complete mixing. Their entire water column was totally saturated with oxygen commencing the period of summer stratification. Most of the lakes however had undergone somewhat less than complete mixing and therefore were commencing the period of high oxygen demand with an inherent oxygen deficit. Mayo Lake (see Page A66 of Appendix A) is an example of a lake which fails to completely overturn and appears to remain permanently stratified. Mixing in Mayo Lake was confined to the upper 12.2 metres (40 feet) of the water column. The bottom 25.9 metres (85 feet) of Mayo Lake has less than 5 mg/L of oxygen throughout the entire ice free period of 1977.

The degree and extent of spring mixing in a lake trout lake obviously has a significant influence on the ability of the lake to assimilate additional nutrients and still maintain suitable water quality conditions for the lake trout species. Lakes with incomplete mixing and reaeration during spring overturn have less oxygen available per unit volume of water and therefore a correspondingly lower nutrient assimilation capacity.

C. Water Temperature

The water quality requirements of lake trout are related to both temperature and oxygen. During the summer stratification period lakes warm from the surface downward and become depleted of oxygen from the bottom upward. The portion of the water column between these two converging factors is the volume of usable lake trout habitat.

Table 3. Oxygen and Temperature Conditions at Bottom of Water Column at or Following Spring Overturn

Lake	Date	Temp. (°C)	Oxygen (mg/L)	Oxygen % Saturation
McMaster	7.5.77	5.2	14.6	114
Paugh	7.5.77	6.7	14.0	114
Purdy	4.5.77	5.3	11.4	90
Clear	13.6.76	7.3	10.8	89
Jamieson	6.5.77	4.3	11.5	88
St. Peter	22.5.76	6.5	10.6	86
Limerick	12.5.77	6.9	10.1	83
Muskrat	25.5.78	5.2	10.2	80
Kamaniskeg (North)	17.5.77	7.6	9.5	79
Halfway - West	8.5.77	4.1	10.2	78
Papineau	5.7.77	6.0	9.5	76
Round	25.5.78	5.0	9.1	75
Diamond (Herschel)	11.5.77	5.0	9.3	73
Wollaston	12.5.77	5.3	9.1	72
Bark	18.5.77	5.2	9.0	71
Kamaniskeg (South)	17.5.77	5.6	8.2	65
Aylen	29.6.78	4.2	8.4	64
L'Amable	9.5.77	3.5	8.1	61
Carson	21.5.77	4.5	7.9	61
Wadsworth	13.5.76	4.1	7.9	60
Big Clear	23.6.78	4.6	7.7	59
Bay	5.5.77	6.0	7.2	58
Kulas (Greenan)	19.5.78	4.2	7.6	58
Cashel	17.5.77	4.7	7.2	56
Colton	18.5.78	4.0	7.4	56
Diamond(Radcliffe)	20.5.77	3.1	7.2	54
Norway	18.5.78	4.0	6.8	52
Burns	14.6.78	4.5	6.5	50
Charlotte	13.5.76	5.3	6.4	50
Lavallee	22.5.76	3.6	6.6	50
Jeffery	10.5.77	4.7	6.3	49
Otter	1.6.76	4.3	6.0	46
Trout (Stubbs)	13.5.76	4.0	5.9	45
McKenzie	4.7.78	3.7	5.5	42
Lower Hay	30.6.78	4.5	5.3	41
Lyell (Cross)	4.7.78	3.9	5.3	41
Halfway - East	6.5.77	3.9	4.9	37
Big Salmon	21.6.78	3.6	4.6	35
McCauley	29.6.78	4.2	4.5	35
Big Mink - North	28.6.78	3.5	4.2	32
Faraday	28.6.78	4.0	3.9	30
Little Clear	20.6.78	4.0	3.6	28
Mephisto	18.5.77	5.0	3.2	25
Weslemkoon	1.6.76	6.5	2.7	22
Green	19.5.77	2.8	2.6	19
Little Salmon	20.6.78	2.5	1.9	14
Raglan	16.5.78	3.4	1.3	10
Mayo	19.5.77	5.0	1.2	9
Limestone(Brougham)	14.6.78	4.2	0.8	6
Wabun	24.5.78	3.7	0.5	4
Trout (Len)	26.6.78	2.6	0.3	2
Limestone (Mayo)	26.6.78	3.0	0.0	0

While human activities have little influence on the temperature of a lake it is nevertheless necessary to examine the temperature of a lake in attempting to assess the suitability of water quality for lake trout survival.

For the most part, the lake trout waters in Eastern Ontario have temperatures of 10°C and higher throughout the top 9 metres (30 feet) of the water column during the summer months. The range however for the fifty-two lakes under consideration was discovered to be from 7.6 metres to 21.3 metres (25 to 70 feet). Table 4 provides data indicating the maximum recorded depth of penetration of the 10°C temperature for each lake. In comparing these data with the corresponding average depths of the lakes, one can see that some lakes have more and other lakes less than fifty percent of the entire lake volume unsuitable for lake trout based only on temperature. In some of the lakes which warm to an atypical depth such as Clear, Kamaniskeg (North) and Limerick, when one subtracts the unsuitable portion of the water column based on temperature from the lake's maximum depth there is obviously only a small volume of water left in which suitable oxygen conditions must be maintained if the lake trout habitat is to be protected. In Bark and Papineau Lakes which also warm to an atypical depth, the lakes are sufficiently deep that there is no significant restriction on usable lake trout habitat caused by temperature factors.

D. Photosynthetic Oxygen Supply

In certain lakes, particularly those which have a high degree of water clarity, sufficient light penetration occurs to permit photosynthetic activity below the 10°C isotherm (i.e. within the zone of usable lake trout habitat). Since photosynthesis (the conversion of nutrients, carbon dioxide and sunlight energy into plant tissue) results in the release

Table 4. Depth of Water Column with Water Temperatures of 10°C or Warmer

Lake	Date	Depth to 10°C metres	(feet)	Mean Depth metres	(feet)
Big Mink - North	16.8.78	5.9	(19.4)	8.5	(27.8)
Wadsworth	17.8.76	7.6	(25.0)	7.2	(23.6)
Raglan	1.9.78	7.8	(25.6)	9.2	(30.3)
Limestone (Mayo)	19.8.78	8.0	(26.2)	12.6	(41.2)
St. Peter	23.8.77	8.2	(27.0)	7.6	(24.9)
Halfway - East	31.8.77	8.2	(27.0)	11.8	(38.6)
Diamond(Radcliffe)	26.8.77	8.2	(27.0)	13.8	(45.3)
McCauley	27.9.78	8.3	(27.2)	6.6	(21.6)
Limestone(Brougham)	2.9.78	8.3	(27.2)	11.1	(36.3)
Little Salmon	4.9.78	8.3	(27.2)	16.7	(54.7)
Wabun	27.8.78	8.3	(27.2)	13.3	(43.6)
Colton	26.8.78	8.3	(27.2)	9.7	(31.8)
Jamieson	23.9.77	8.5	(28.0)	8.5	(27.9)
Kulas (Greenan)	25.9 78	8.5	(28.0)	8.1	(26.5)
Otter	12.8.76	8.5	(28.0)	8.6	(28.2)
Lyell (Cross)	2.10.78	8.6	(28.2)	10.6	(34.8)
McMaster	23.9.77	8.8	(29.0)	7.8	(25.6)
Carson	25.8.77	8.8	(29.0)	12.3	(40.4)
Trout (Len)	1.10.78	9.0	(29.5)	14.5	(47.5)
Mephisto	18.8.77	9.1	(30.0)	16.2	(53.2)
Charlotte	8.9.76	9.1	(30.0)	7.4	(24.3)
Trout (Stubbs)	8.9 76	9.1	(30.0)	15.4	(50.5)
Diamond (Herschel)	17.8.77	9.1	(30.0)	8.3	(27.2)
Jeffery	23.8.77	9.1	(30.0)	12.5	(41.0)
Lavallee	18.8.76	9.1	(30.0)	13.3	(43.6)
Little Clear	4.9.78	9.3	(30.5)	17.5	(57.5)
L'Amable	23.8.77	9.4	(31.0)	19.6	(64.3)
Halfway - West	23.8.77	9.4	(31.0)	8.5	(27.9)
Burns	2.9.78	9.5	(31.2)	11.3	(37.2)
Faraday	2.10.78	9.8	(32.1)	9.0	(29.5)
Lower Hay	27.9.78	9.8	(32.1)	9.3	(30.5)
Mayo	23.9.77	9.8	(32.1)	7.6	(24.9)
Bay	17.8 77	9.8	(32.1)	10.3	(33.8)
Big Salmon	4.9.78	10.0	(32.8)	13.3	(43.6)
Norway	26.9.78	10.0	(32.8)	9.4	(30.8)
Wollaston	29.8.77	10.1	(33.0)	9.4	(30.8)
Paugh	23.8.77	10.1	(33.0)	14.1	(46.3)
Cashel	18.8.77	10.4	(34.0)	7.8	(25.6)
McKenzie	27.9.78	10.8	(35.4)	9.0	(29.5)
Purdy	31.8.77	11.0	(36.0)	9.0	(29.5)
Green	30.8.77	11.0	(36.0)	16.8	(55.0)
Big Clear	4.9.78	11.0	(36.0)	20.1	(66.0)
Kamaniskeg (South)	24.8.77	11.3	(37.0)	13.4	(43.8)
Weslemkoon	24.8.77	12.2	(40.0)	9.3	(30.5)
Aylen	27.9.78	12.5	(41.0)	27.1	(89.1)
Round	29.9.78	13.0	(42.6)	13.2	(43.2)
Limerick	21.8.77	13.7	(45.0)	8.4	(27.6)
Bark	21.8.77	14.9	(49.0)	24.3	(79.6)
Kamaniskeg (North)	23.9.77	15.2	(50.0)	8.8	(29.0)
Muskrat	1.9.78	16.0	(52.5)	17.7	(58.2)
Papineau	28.7.77	18.3	(60.0)	18.3	(60.0)
Clear	30.8.77	21.3	(69.9)	11.2	(36.7)

of oxygen it is possible to have oxygen being supplied to the bottom waters of a lake during the summer months. In lakes where this represents a significant source of oxygen a slight increase in chlorophyll level (suspended plant matter) resulting from further phosphorus supplies could reduce the depth of light penetration and totally eliminate this photosynthetic source of oxygen. This in turn could bring about a rapid and serious deterioration of the oxygen condition in the deep waters of the lake. Table 5 provides a comparison of the oxygen condition of Diamond Lake (Herschel Township) and Bay Lake. Diamond Lake exhibits a typical situation in which the oxygen levels are highest at the surface and uniformly become depleted with depth. Bay Lake demonstrates the occurrence of strong photosynthetic activity with elevated oxygen concentrations part way down the water column.

E. Metalimnetic Oxygen Depletion

A further natural phenomenon that has been found to occur in a small number of lakes in Southeastern Ontario is that of oxygen depletion within the middle strata (metalimnion) of the water column. An example of this is provided in Table 6 which compares the oxygen conditions of Muskrat Lake and Big Clear Lake for two dates in 1978.

Big Clear Lake exhibits a situation in which oxygen super-saturation occurs in the middle strata and then is uniformly depleted to the bottom. Muskrat Lake demonstrates the rare occurrence of oxygen depletion between 10 metres (32.8 feet) and 15 metres (49.2 feet) depth followed by a noticable increase below 15 metres (49.2 feet).

Table 5. Comparison of Diamond (Herschel) Lake and Bay Lake Illustrating Photosynthetic Oxygen Supply in Bay Lake

Depth metres (feet)	Diamond June 24/77 (O_2 mg/L)	Diamond Aug. 17/77 (O_2 mg/L)	Bay June 28/77 (O_2 mg/L)	Bay Aug. 17/77 (O_2 mg/L)
Surface	9.8	7.7	9.5	9.0
2.7 (9)	9.8	7.9	9.7	8.9
4.6 (15)	9.3	7.9	10.1	8.8
6.1 (20)	9.8	7.3	12.1	8.7
7.3 (24)	8.3	6.4	12.3	8.7
7.9 (26)	7.8	5.8	12.3	11.5
9.1 (30)	5.6	3.3	11.7	11.4
10.1 (33)	4.8	2.9	11.5	10.5
11.0 (36)	4.5	2.3	10.8	10.5
12.8 (42)	4.2	1.8	9.1	9.5
13.7 (45)	4.3	1.6	7.9	8.9
14.6 (48)	4.3	1.6	6.8	7.9
16.5 (54)	3.8	1.6	6.6	5.6
18.3 (60)	2.2	1.0	-	3.1
20.1 (66)	0.8	0.1	-	0.8
21.0 (69)	0.3	0.1	-	0.7

Table 6. Comparison of Muskrat Lake and Big Clear Lake Illustrating Metalimnetic Oxygen Depletion for Muskrat Lake

Depth metres	(feet)	Big Clear Aug. 2/78 (O_2 mg/L)	Big Clear Sept.4/78 (O_2 mg/L)	Muskrat Aug. 22/78 (O_2 mg/L)	Muskrat Sept.11/78 (O_2 mg/L)
1.0	(3.3)	9.0	8.7	10.3	9.4
3.0	(9.8)	8.8	9.1	7.8	9.5
5.0	(16.4)	8.8	8.9	7.6	9.3
7.0	(23.0)	9.0	9.0	7.3	9.2
8.0	(26.2)	12.5	9.0	7.0	8.9
8.5	(27.9)	13.6	10.0	5.5	8.6
9.0	(29.5)	13.4	10.5	3.5	8.3
9.5	(31.2)	13.3	10.7	2.1	8.1
10.0	(32.8)	13.4	12.8	0.9	5.8
10.5	(34.4)	13.4	12.9	0.2	4.5
11.0	(36.1)	13.4	13.1	0.2	2.0
12.0	(39.3)	13.2	13.2	0.5	0.5
13.0	(42.6)	12.8	12.9	0.9	0.8
14.0	(45.9)	12.8	13.0	1.6	1.6
15.0	(49.2)	13.0	13.2	2.3	2.5
17.0	(55.8)	-	-	3.5	3.9
20.0	(65.6)	10.0	10.9	4.4	4.9
25.0	(82.0)	8.2	9.0	4.8	5.1
30.0	(98.4)	8.1	8.5	4.2	4.5
35.0	(114.8)	-	7.6	2.9	3.0
44.0	(144.3)	8.2	7.4	1.4	1.4
56.0	(183.7)	-	3.4	1.4	-

The normal situation in a lake trout lake is that of the oxygen being depleted from the lake bottom upwards (hypolimnetic oxygen depletion). Metalimnetic oxygen depletion results in oxygen concentrations being lower in the middle portion of the water column with higher concentrations above and below the zone of depletion.

While explanations for the occurrence of metalimnetic oxygen depletion can be found in the technical literature, the correct explanation for the occurrences in these study lakes is not known. In the case of Muskrat Lake the occurrence is prolonged and very pronounced. In other study lakes the occurrence is weak, not prolonged and does not occur each year.

F. Flushing Rate

A further factor having an influence on a lake's dissolved oxygen resource is that of water exchange or flushing action. A lake's flushing rate refers to the time required for water entering a lake, assuming that it becomes totally mixed, to leave the lake as outflow. Lakes with substantial flushing action are able to discharge nutrients and some of the organic matter which they produce thereby lessening the demand on the oxygen resource of its bottom waters. Table 7 provides a comparison between Jamieson and Halfway-West which illustrates the influence of flushing action. The lakes are similar in most respects with the exception of their flushing rates and oxygen conditions. The difference in oxygen condition is considered to be related to the substantial flushing action of Halfway (West) Lake.

While flushing action provides the only apparent explanation for oxygen conditions in several of the study lakes which have better oxygen conditions than expected, it should be noted that the oxygen conditions in other study lakes appear to be uninfluenced by seemingly significant flushing rates.

Table 7. Comparison of Jamieson Lake and Halfway (West) Lake Illustrating Influence of Flushing Rate on Oxygen Conditions

	Jamieson	Halfway - West
Chlorophyll	0.9 ug/L	1.0 ug/L
Surface Area	48.2 hectares (119 acres)	96 hectares (237 acres)
Mean Depth	8.5 metres (27.9 feet)	8.5 metres (27.9 feet)
Flushing Rate	0.7 times per year	7.0 times per year

DISSOLVED OXYGEN CONDITION

Depth metres	(feet)	Jamieson August 19, 1977 (O_2 mg/L)	Halfway - West August 23, 1977 (O_2 mg/L)
4.6	(15)	8.9	9.1
7.6	(25)	8.0	9.2
9.6	(31)	6.4	7.6
11.3	(37)	4.9	6.5
13.7	(45)	3.5	6.3
16.8	(55)	2.5	6.4
19.8	(65)	1.2	6.4
21.3	(70)	0.1	6.3

It is possible that other unidentified factors could play an equally important role or combined role with the flushing rate to create the conditions observed.

INTERIM WATER QUALITY MANAGEMENT RECOMMENDATIONS

The information and discussion in the preceeding sections has been provided for the purpose of outlining the lake processes and various factors to be considered in drawing conclusions concerning the sensitivity of a lake trout lake to water quality change resulting from further nutrient inputs. The actual assessment of the sensitivity of any given lake can be approached in various ways. Mathematical models currently exist and are progressively being refined which will ultimately provide the ability to predict in absolute terms the potential water quality implications of additional nutrient inputs to lakes. Resource managers recognize however that these models and indeed all available assessment techniques are currently incapable of totally unravelling the complex nutrient-algae-dissolved oxygen relationships in lakes. For this reason, the subsequent assessment of the sensitivity of the fifty-two lakes considered in this report is based on an empirical knowledge of lake processes and interpretation of the available data base for each lake. It permits only an indication of the relative sensitivity of the lake (i.e. one to another).

In general terms the empirical relationships indicate that the lake trout lakes least sensitive to a unit increase in nutrient supply are those with the greatest mean depths, largest surface areas, most substantial flushing rates and most complete mixing during spring overturn. Conversely, the lake trout lakes most vulnerable to water quality change from a unit increase in nutrient supply are those with the shallowest mean depths, smallest surface areas, lowest flushing rates and least complete mixing during spring overturn.

This report will complete the Southeastern Region's preliminary assessment of one hundred and four lake trout waters (see also reference No. 3). From these one hundred and four lakes, many combinations of the above-mentioned factors have been identified and studied. It has become abundantly clear that the factors cited do not warrant equal weighting and with few exceptions the single most significant factor determining the dissolved oxygen condition of a lake trout lake is its mean depth. The other factors serve to modify to a greater or lesser extent the influence of a lake's mean depth.

For management purposes, the fifty-two lakes considered in this report have been divided into three groups which describe to the best of our ability their relative sensitivities to water quality change resulting from further nutrient inputs. Associated with each of the three groupings are recommendations which reflect the Ministry's degree of concern over additional phosphorus supplies reaching the lakes. The technical basis for the recommendations provided is outlined in Appendix C.

The recommendations are interim in nature and will be re-assessed by the Ministry within five years of the date of release of the report. Furthermore it should be noted that the interim recommendations are not intended to replace any existing local planning policies which are more stringent than those recommended in this report. Nor do they remove the necessity for site inspections by the various authorities involved in determining the suitability for development of any specific parcel of shoreline property.

It should also be noted that while the recommendations are directed specifically towards shoreline development, the actual intent of the recommendations is to control phosphorus inputs to the sensitive lakes. For this reason, any land owner seriously affected by the following recommendations

is encouraged to contact the Ministry of the Environment's Regional Office in Kingston. Advice will be provided on alternative to conventional 'ribbon type' shoreline development which might allow development of a parcel of land while satisfying the intent of the recommendations.

Highly Sensitive Lake Trout Lakes

The lake trout waters included in this category are those which are considered to require extreme precautionary measures to prevent further phosphorus inputs. They include the lakes considered to have both a high potential for increased algal production and further dissolved oxygen depletion. Colton and Norway Lakes while currently not being managed for lake trout both appear to have water quality conditions capable of supporting the species. The oxygen resource of both Colton and Norway Lakes is considered to be highly susceptible to depletion. In consultation with and at the concurrence of the Council of the County of Renfrew, both of these lakes were being included in the highly sensitive category in the hope that lake trout can and will be introduced into these waters. The specific assessment for each lake is provided in Appendix A. The lakes considered to be highly sensitive to further nutrient inputs are as follows.

Lake	Township
Bay	Faraday
Big Mink	McClure
Cashel (Little Salmon)	Cashel
Charlotte	Brudenell
Colton	Admaston
Diamond	Herschel
Faraday	Faraday
Jamieson	Dungannon
Jeffery	Faraday

Highly Sensitive Lakes (Cont'd)

Lake	Township
Limestone	Mayo
Limestone	Brougham
Little Salmon	Bedford
Mayo (Crooked)	Mayo
McMaster	Sherwood, Jones & Burns
Norway	Bagot
Raglan	Raglan
Trout (Len)	Ashby
Wabun	Brougham

In addition to controlled shoreline development on these lakes nutrient loadings from disturbances in the upstream drainage basin may have to be restricted.

For the above-mentioned lakes, the following recommendations are made for the purpose of protecting lake water quality conditions.

1. No new lots with lakeshore frontage be created either by means of severance or through plan of subdivision.

2. No new tent or trailer parks or tourist establishments or enlargements of an existing tent or trailer park or tourist establishment with lakeshore frontage be permitted.

3. No further erection of multiple dwellings for rent or lease be permitted on an existing developed parcel of land with lakeshore frontage.

4. Development on existing vacant registered lots with lakeshore frontage only be permitted under the following conditions.

i) No more than one family dwelling unit be permitted on a single vacant lot.

ii) Permits issued by the appropriate Health Unit for a private waste disposal system be made conditional upon the systems being located 30.5 metres (100 feet) from the shoreline of the lake or otherwise as remote from the shoreline as the lot will permit.

iii) Where the private waste disposal system involves an underground tile bed, the fill material utilized to construct the tile bed is to be of a composition known to the Health Unit as having a suitable phosphorus retention capability.

iv) The Municipality responsible for issuing the building permit for a vacant registered lot is encouraged to make the permit conditional upon the dwelling being set back as far from the shoreline as is practical taking into consideration the size, shape and topography of the lot in question. Wherever feasible, the set back should be at least 30.5 metres (100 feet).

v) The property between the shoreline of the lake and the dwelling or private waste disposal system should be retained in its natural state to serve as a buffer to assist in minimizing the land-surface transport of nutrients to the lake.

5. No dredging or filling activities be permitted within the littoral zone of the lake which would result in the resuspension of nutrients from the lake's sediments.

Moderately Sensitive Lake Trout Lakes

The lake trout waters included in this category are those which are considered capable of supporting additional shoreline development provided that special precautions are taken to ensure that maximum containment of phosphorus occurs on the lots to be developed. Included are lakes with

One of the following combinations: a moderate potential to produce more algae and a moderate potential to undergo further oxygen depletion; a relatively high potential to produce more algae but a moderately insensitive dissolved oxygen resource; or a low potential to produce more algae but a high relative sensitivity to futher oxygen depletion. The lakes in general have good water quality conditions for lake trout however are considered to be moderately susceptible to further oxygen depletion. Also included in this grouping of lakes are Kulas (Greenan), Purdy, and Wadsworth which presently are not being managed as lake trout fisheries but appear to have water quality conditions suitable to support this species. They have been included in this report to provide protection during the interim period and an opportunity for Natural Resources to re-assess their lake trout management potential. While it is not considered necessary to impose restrictions on the number of new lots being created (based on water quality considerations), the Ministry of the Environment will monitor the number of lots being created. On a case by case basis, it might become necessary to recommend restrictions if the trend reveals concentrated development pressure on any one of the lakes in this grouping. The specific assessment for each lake is provided in Appendix A. The lakes included in this category are as follows.

Lake	Township
Big Salmon	Bedford, Lougborough
Burns	Griffith
Clear	Sebastopol
Diamond	Radcliffe
Green	Brougham
Halfway-East	Radcliffe
Halfway-West	Radcliffe
Kamaniskeg-North (Barry's Bay)	Sherwood, Bangor
Kulas (Greenan)	Jones, Sherwood
Lavallee	Faraday
Limerick	Limerick
Little Clear	Bedford
McCauley	Airy & Murchison
McKenzie	Sabine
Purdy (Loon)	Bangor, Wicklow, McClure
St. Peter	McClure
Wadsworth	Radcliffe
Wollaston (Eagle)	Wollaston

For the above-mentioned lakes the following recommendations are made.

1. The approval of any new lot with shoreline frontage either by means of severance or through plan of subdivision should be restricted to a single dwelling structure and should be conditional upon the structure and associated private waste disposal systems being not closer than 30.5 metres (100 feet) from the shoreline of the lake.

2. It is further recommended that the title for any new lot with shoreline frontage have a suitable condition inserted which would prohibit any disturbance of the natural soil mantle and provide protection against removal of the mature tree cover within 30.5 metres (100 feet) of the shoreline of the lake.

3. Any new tent or trailer park or tourist establishment or expansion of an existing tent or trailer park or tourist establishment with shoreline frontage should not be permitted within a minimum distance of 30.5 metres (100 feet) of the shoreline of the lake. An even greater set back is encouraged for this type of development.

4. Construction of more than one dwelling on any existing developed lot with shoreline frontage should be discouraged but if permitted should be conditional on the structure and private waste disposal system being not closer than 30.5 metres (100 feet) from the shoreline of the lake.

5. All new permits issued by the Health Unit for private waste disposal systems which involve construction of tile beds on lots with shoreline frontage should be conditional upon the use of a fill material known to have a good phosphorus retention capability.

6. Development on existing vacant registered lots with lakeshore frontage should only be permitted under the following conditions.

i) No more than one structure or dwelling be permitted on any single vacant lot.

ii) Permits issued by the Health Unit for a private waste disposal system be conditional upon the system being located 30.5 metres (100 feet) from the shoreline of the lake or otherwise as remote from the shoreline as the lot will permit.

iii) The Municipality responsible for issuing the building permit for a vacant registered lot is encouraged to make the permit conditional upon the dwelling being set back as far from the shoreline as is practical taking into consideration the size, shape and topography of the lot in question. Wherever feasible a set back should be at least 30.5 metres (100 feet).

v) The property between the shoreline of the lake and the dwelling or private waste disposal system should be retained in its natural state to serve as a buffer which will assist in minimizing the land-surface transport of nutrients to the lake.

7. Dredging and/or filling activities involving the littoral zone of the lake should be discouraged in order to avoid the resuspension of nutrients from the lake's sediments.

Low Sensitivity Lake Trout Lakes

All of the lakes included in this category are considered to have oxygen resources which are relatively insensitive to depletion. Additional phosphorus inputs associated with normal shoreline development would not be expected to result in a significant water quality deterioration. For

this reason, the Province's existing regulations pertaining to private waste disposal systems are considered adequate for the purpose of preventing a deterioration of the lake trout habitat in the lakes included in this category. However, it would be in the interest of all lake users if seasonal dwellings and private waste disposal systems were set back as far as possible from the shoreline and that disturbance of the natural vegetation be minimized to maintain the aesthetic appeal of an uninhabited lake. These measures will also minimize the potential for production of troublesome localized weed growths. The specific assessment for each lake is provided in Appendix A. The lakes included in this category are as follows.

Lake	Township
Aylen	Dickens
Bark	Jones, Lyell
Big Clear	Bedford
Carson	Jones, Sherwood
Cross (Lyell)	Lyell
Kamaniskeg-South Basin	Bangor
L'Amable	Faraday
Lower Hay	Sabine
Mephisto (Devil)	Cashel
Muskrat	Westmeath & Ross
Otter (Cotter)	Ashby
Papineau	Wicklow, Bangor
Paugh	Sherwood
Round	Richards & Hagarty
Trout (Stubbs)	Jones, Sherwood
Weslemkoon	Ashby, Effingham

GENERAL RECOMMENDATIONS

1. All cottage owners with private waste disposal systems which would be considered substandard in terms of existing regulations are encouraged to voluntarily contact the Health Unit for assistance in determining how their system could be upgraded in the interest of water quality protection. It is particularly important for health reasons that substandard systems which may be contributing bacteria to the lake be upgraded. It is also important that cottage owners on the lakes identified in this report as being highly or moderately sensitive to nutrient inputs upgrade substandard systems in order to assist in protecting the lake trout populations.

2. Cottage owners can also minimize phosphorus inputs to lakes by:

i) Reducing the quantity of water utilized for domestic purposes.

ii) Avoiding the temptation to install an automatic dishwasher and/or minimizing the use of an automatic dishwasher since these conveniences require a high phosphate content detergent.

iii) Avoiding the temptation to create a cottage lawn and the use of fertilizer on a cottage lawn which might already have been created.

iv) Planting trees or shrubs to increase the amount of vegetation cover on a cottage lot.

v) Minimizing the disturbance of the lake sediments fronting the cottage lot.

3. While the findings of this Lake Survey Program would undoubtedly be of interest to the property owners on the lakes studied, our files contain only a small number of contact persons for only a few lakes. In order to facilitate effective two-way communication between MOE and the property owners on Southeastern Ontario's lakes, we would encourage the property owners to form a single association for each lake and forward its name and mailing address to the Ministry.

4. The resources of the Ministry of the Environment are limited and there are many lakes which require survey work. For this reason, the Southeastern Region of the Ministry of the Environment would encourage property owners associations to become involved in a "Self-Help Water Quality Monitoring Program". With very little effort, the property owners association can make a valuable contribution to the Ministry's water quality management program. Information pertaining to the "Self-Help" program can be obtained from the Ministry of the Environment, Southeastern Regional Office, 133 Dalton Street, P.O. Box 820, Kingston, Ontario K7L 4X6.

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4. Dillon, P.J. and F.H. Rigler. 1975. A Simple Method for Predicting the Capacity of a Lake for Development Based on Lake Trophic Status. Journal of the Fisheries Research Board of Canada. Vol. 32, No. 9, p 1519-1531.

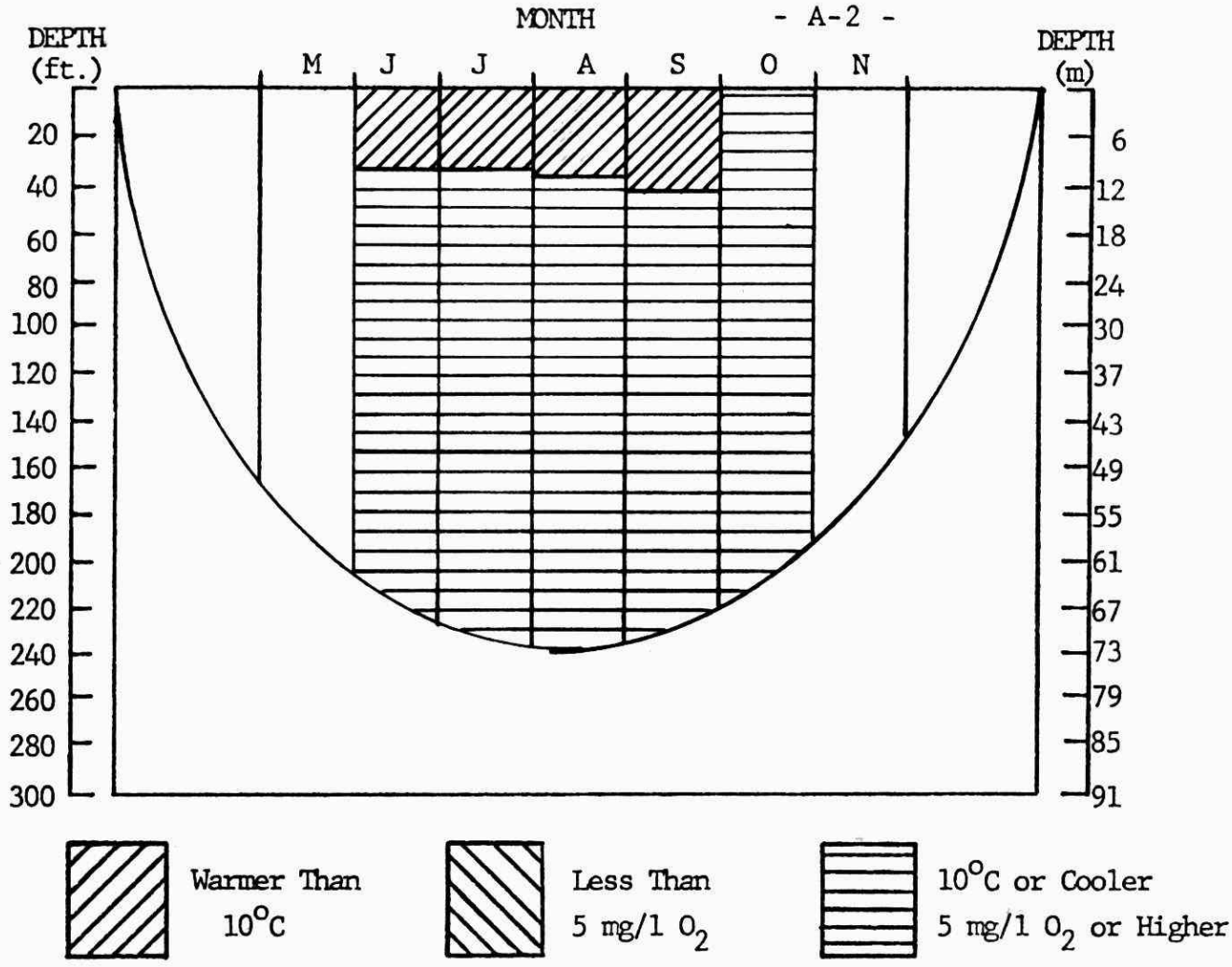
5. Aitkens, D.F. 1975. Phosphorus Retention Capability of Granular Soils on a Portion of the Precambrian Shield. Ontario Ministry of the Environment.

6. Ontario Ministry of the Environment. 1977. Phosphorus Retention Capability of Granular Soils on the Precambrian Shield North of Kingston.

APPENDIX A

Appendix A provides, in alphabetical order, individual data summary sheets for each of the lake trout waters studied. In many cases more than one sampling site was studied on a lake. The summary sheets provide data for only the deepest sampling station on each lake and therefore probably illustrates the best water quality conditions for each body of water. The dissolved oxygen and temperature profiles illustrated on each summary sheet show depth but not area or volume to scale. Unless otherwise noted on the summary sheets, the chlorophyll and Secchi disc data provided are seasonal averages from ice-out to freeze-up and based on 11 to 14 samples.

While the complete data base for the lakes studied is far too extensive to be included in this report, tabulations are retained on file at Environment's Regional Office and will also be inserted into the Ministry's computerized data storage for future reference and further analysis.



Aylen Lake

The 1978 survey of Aylen Lake revealed excellent water quality for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles of Aylen Lake (illustrated above) indicate excellent lake trout habitat. The lake's entire water column contained suitable oxygen conditions for lake trout.

Aylen Lake supports an existing cottage density of one unit per 9.4 hectares (23.2 acres) of lake surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be low. Similarly, because of the lake's large depth and volume of bottom water, its oxygen resource is considered to have a low susceptibility to depletion.

It is concluded that further shoreline development on Aylen Lake would have little effect on water quality conditions.

Aylen Lake

Location: District of Nipissing
Dickens Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	2015 hectares (4980 acres)
Mean Depth	27.1 metres (88.9 feet)
Max. Depth	73 metres (239 feet)
Volume	546.1 x $10^6 m^3$ (442,713 acre-feet)
Watershed Area	172 km^2 (66.4 square miles)
Flushing Rate	0.1 times per year

Shoreline Development

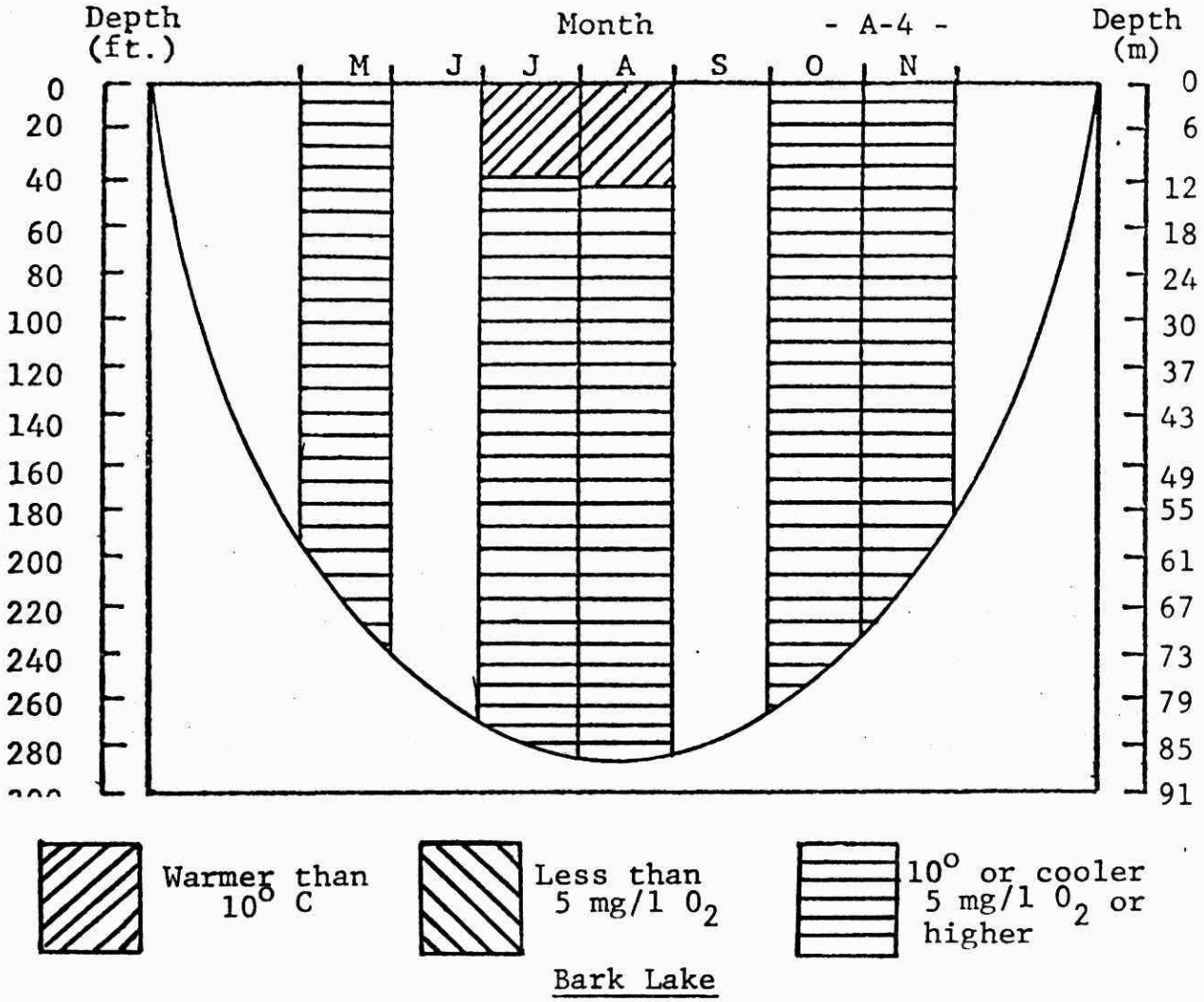
cottages, homes	213, 2
vacant lots	information not available
tourist camps	1
tent, trailer sites	0
% shoreline crown	50%
% shoreline patent	50%

Estimated Phosphorus Supply (Annual)

Upstream lakes		
Land runoff	*834 kg (1835 lbs)	35%
Atmosphere	1511 kg (3324 lbs)	62%
Shoreline Development	140 kg (308 lbs)	3%
Sensitivity Index	2	

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.2	20.3	1.2	9	10	30	6.4	278	0.08	6.7-7.1

* Phosphorus input from upstream lakes included in estimate from land runoff.



Bark Lake

The 1977 survey of Bark Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles of Bark Lake (illustrated above) indicate excellent lake trout habitat. The lake's entire water column contained suitable oxygen conditions for lake trout.

Bark Lake supports an existing cottage density of one unit per 131.1 hectares (324 acres) of lake surface area. Development of the registered vacant lots would increase the cottage density to one unit for each 77.7 hectares (192 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be low. Similarly, because of the lake's large depth and volume of bottom water, its oxygen resource is considered to have a low susceptibility to depletion.

It is concluded that further shoreline development on Bark Lake would have little effect on water quality conditions.

Bark Lake

Location: Renfrew County
Jones Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	3798 hectares (9386 acres)
Mean Depth	24.3 metres (79.6 feet)
Max. Depth	87.5 metres (287 feet)
Volume	3324.1 x $10^6 m^3$ (2,694,800 acre-feet)
Watershed Area	2719.5 km^2 (1050 square miles)
Flushing Rate	0.29 times per year

Shoreline Development

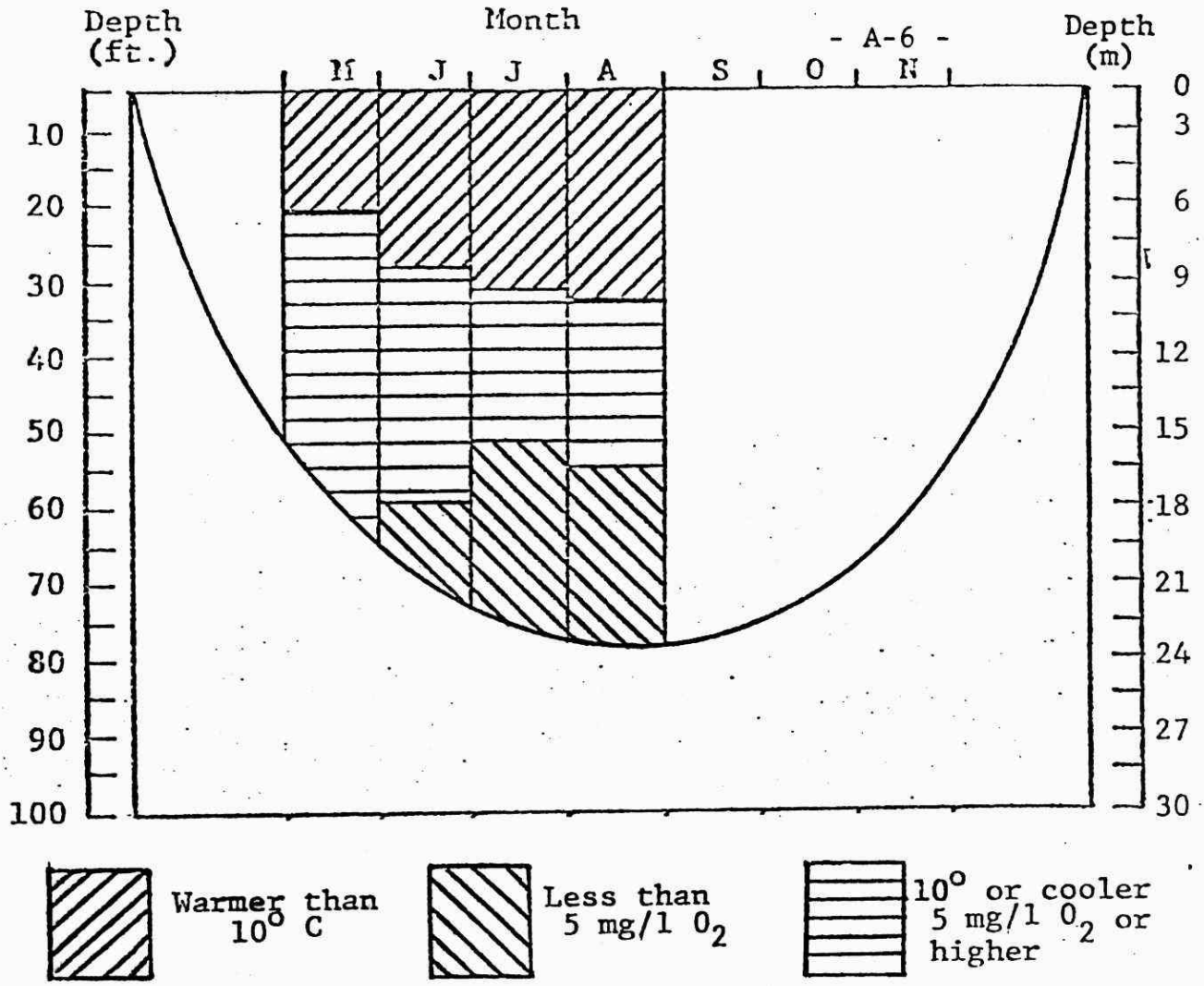
cottages, homes	29
vacant lots	20
tourist camps	3
tent, trailer sites	44
% shoreline crown	75
% shoreline patent	25

Estimated Phosphorus Supply (Annual)

Upstream lakes		
Land runoff	*14342.3 kg (31,619 lbs)	88%
Atmosphere	1894.2 kg (4,176 lbs)	12%
Shoreline Development	35.4 kg (78 lbs)	Nil
Sensitivity Index	0.2	

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.0	19.7	1.0	13	7	30	8	219	0.11	6.3-7.3

* Phosphorus input from upstream lakes included in estimate from land runoff.


Depth (ft.)
Month
M J J A S O N
Depth (m)
10 20 30 40 50 60 70 80 90 100
0 3 6 9 12 15 18 21 24 27 30
Warmer than 10° C
Less than 5 mg/1 O_2
10° or cooler 5 mg/1 O_2 or higher

Bay Lake

The 1977 survey of Bay Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Bay Lake (illustrated above) indicate good lake trout habitat. Approximately 6.1 metres (20 feet) of the lake's water column contains suitable oxygen conditions for lake trout at least until late summer.

Bay Lake supports an existing cottage density of one unit for each 1.5 hectares (3.6 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 1.0 hectare (2.5 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. While the lake is moderately deep, the detailed oxygen data (see Table 5) indicates that photosynthetic oxygen supply is important in maintaining the oxygen resource of the bottom waters. The lake's oxygen resource is therefore considered to be highly susceptible to depletion.

It is concluded that further shoreline development on Bay Lake could cause a significant increase in algal production and depletion of the lake's oxygen resource.

Bay Lake

Location: Hastings County
Faraday Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	87 hectares (215 acres)
Mean Depth	10.3 metres (33.8 feet)
Max. Depth	24.1 metres (79 feet)
Volume	9.0 x $10^6 m^3$ (7300 acre-feet)
Watershed Area	7.10 km^2 (2.74 square miles)
Flushing Rate	0.3 times per year

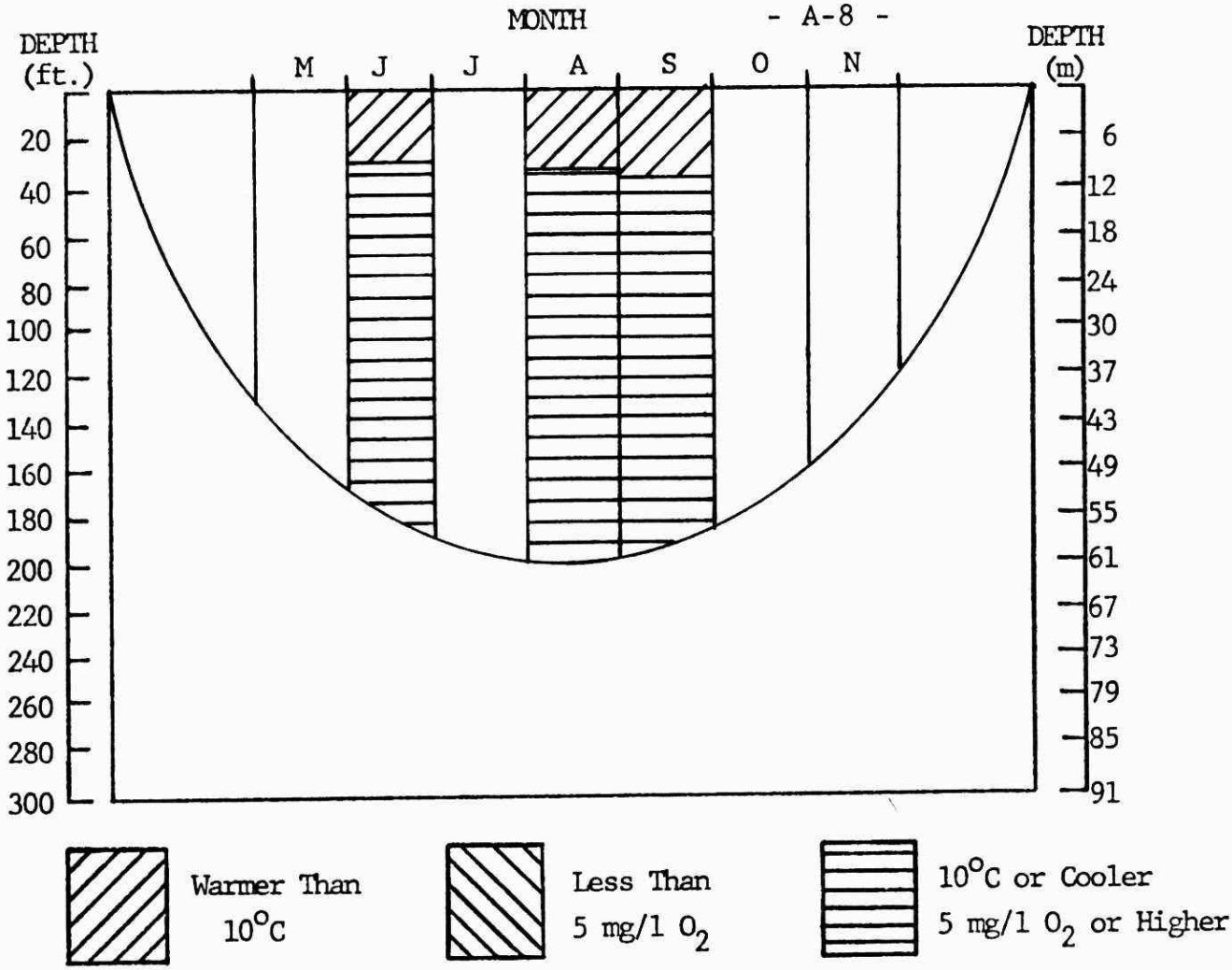
Shoreline Development

cottages, homes	59
vacant lots	28
tourist camps	1
tent, trailer sites	10
% shoreline crown	3
% shoreline patent	97

Estimated Phosphorus Supply (Annual)

Upstream lakes	15.0 kg (33 lbs)	11%
Land runoff	14.1 kg (31 lbs)	10%
Atmosphere	44.1 kg (97 lbs)	31%
Shoreline Development	69.1 kg (152 lbs)	48%
Sensitivity Index	159	

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
7.9	25.9	0.7	5	100	119	8	222	0.13	8.2-8.2



Big Clear Lake

The 1978 survey of Big Clear Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Big Clear Lake (illustrated above) indicate excellent lake trout habitat. The lake's entire water column contained suitable oxygen conditions for lake trout.

Big Clear Lake supports an existing cottage density of one unit per 14.4 hectares (35.5 acres) of lake surface area. Development of the registered vacant lots would increase the cottage density to one unit for each 8.5 hectares (21.0 acres) of lake surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. Because of the lake's large depth and volume of bottom water, the susceptibility to depletion of its oxygen resource is considered to be low.

It is concluded that further shoreline development on Big Clear Lake would have little effect on water quality conditions.

Big Clear Lake

Location: Frontenac County
Bedford Township

Watershed: Cataraqui River

Morphometry Hydrology

Surface Area	187 hectares (463 acres)
Mean Depth	20.1 metres (66 feet)
Max. Depth	61 metres (200 feet)
Volume	37.6 x $10^6 m^3$ (30,558 acre-feet)
Watershed Area	6.63 km^2 (2.56 square miles)
Flushing Rate	0.07 times per year

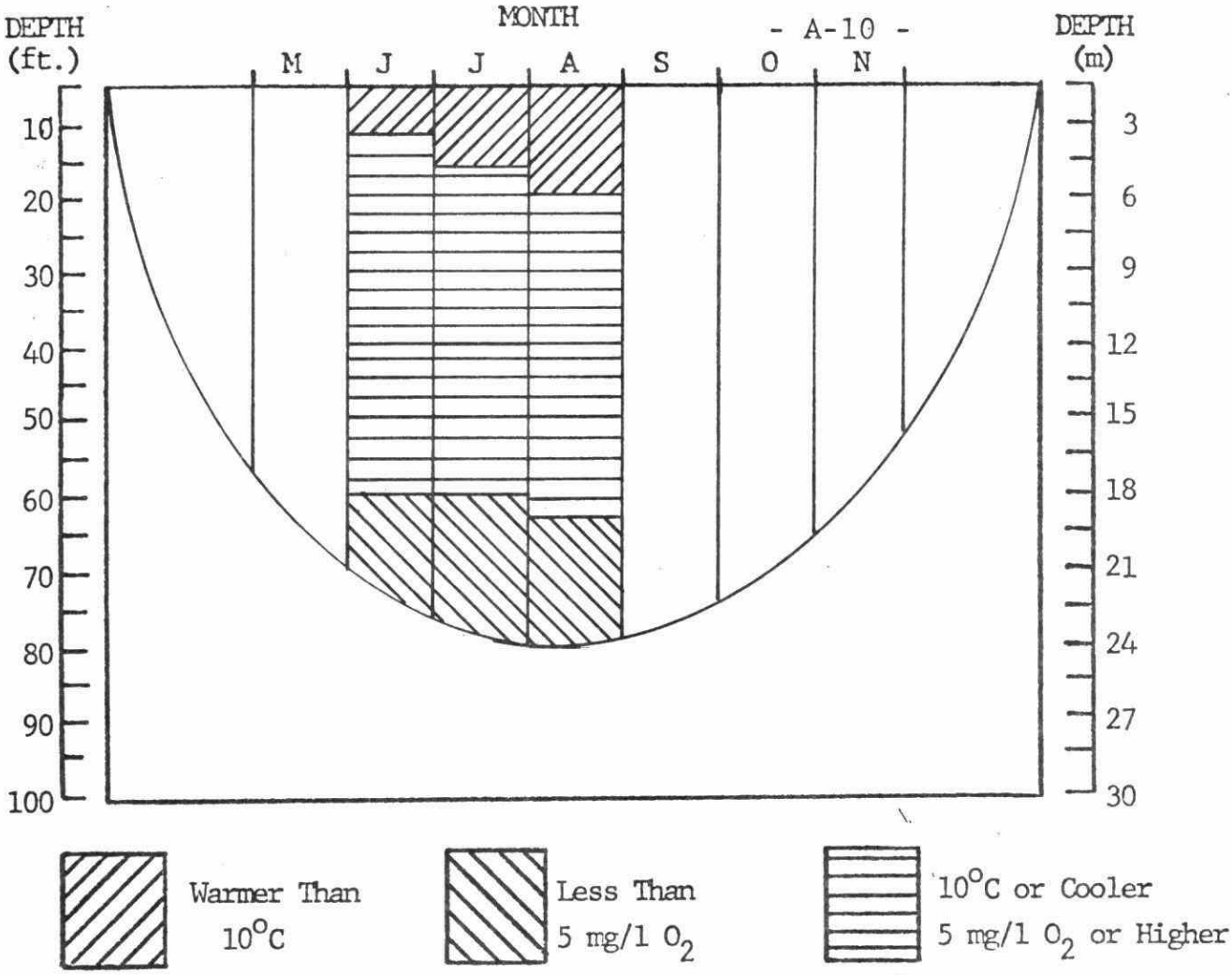
Shoreline Development

cottages, homes	13
vacant lots	9
tourist camps	Nil
tent, trailer sites	Nil
% shoreline crown	40
% shoreline patent	60

Estimated Phosphorus Supply (Annual)

Upstream lakes	4.6 kg	(10.2 lbs)	2%
Land runoff	26.2 kg	(57.6 lbs)	15%
Atmosphere	140.5 kg	(309.1 lbs)	80%
Shoreline Development	4.93 kg	(10.8 lbs)	3%
Sensitivity Index	59		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
8.4	27.6	1.3	3	22	49	7	227	.08	7.0-7.5



Big Mink Lake (North Basin)

The 1978 survey of Big Mink Lake revealed excellent water quality for recreational use. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding good water clarity.

Temperature and oxygen profiles of Big Mink Lake (illustrated above) indicate excellent lake trout habitat. Big Mink Lake exhibited a middle water column oxygen deficit for July and August however the deep water oxygen resource remained suitable for trout.

The north basin of Big Mink Lake supports an existing cottage density of one unit per 2.3 hectares (5.6 acres). Development of the registered vacant lots would increase the density to one unit per 2.2 hectares (5.3 acres).

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal density, decreased water clarity) is considered to be high. The oxygen resource is excellent at present however when the middle water oxygen depletion is considered, the oxygen resource appears to be moderately susceptible to depletion.

It is concluded that further shoreline development on the north basin of Big Mink Lake would cause a decrease in the surface water quality and a depletion of the oxygen resource.

Big Mink Lake (North Basin)

Location: Hastings County
McClure Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	80.0 hectares (197.7 acres)
Mean Depth	8.5 metres (27.9 feet)
Max. Depth	23.9 metres (78.4 feet)
Volume	6.8 x $10^6 m^3$ (5512.6 acre-feet)
Watershed Area	5.2 km^2 (2.0 square miles)
Flushing Rate	0.2 times per year

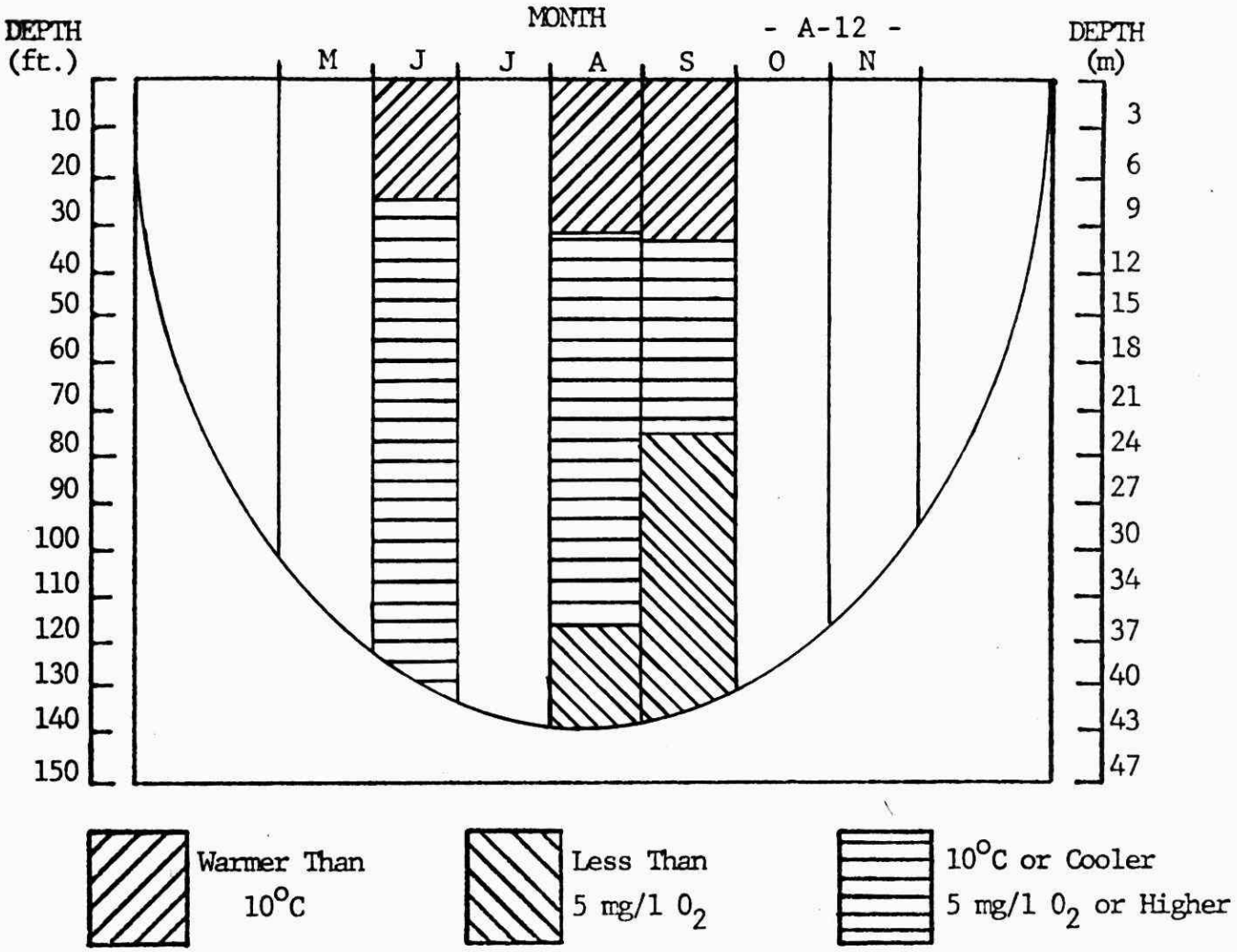
Shoreline Development

cottages, homes	35 - from topo map Whitney 31E/8 1971
vacant lots	2
tourist camps	0
tent, trailer sites	0
% shoreline crown	60
% shoreline patent	40

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil	
Land runoff	24.2 kg (53.2 lbs)	23%
Atmosphere	60.0 kg (132.0 lbs)	57%
Shoreline Development	21.6 kg (47.5 lbs)	20%
Sensitivity Index	197	

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
3.8	12.5	2.3	26	8	28	11	329	0.13	6.5-6.6



Big Salmon Lake

The 1978 survey of Big Salmon Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles of Big Salmon Lake (illustrated above) indicate excellent lake trout habitat.

Based on the information provided in Table 1, the potential of shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Because the lake has a large deep water volume and deep mean depth, the oxygen resource has a low susceptibility to depletion.

It is concluded the shoreline development may affect the surface water quality however the oxygen resource is considered stable.

Big Salmon Lake

Location: Frontenac County
Bedford and Loughborough Townships

Watershed: Cataraqui River

Morphometry Hydrology

Surface Area	148 hectares (366 acres)
Mean Depth	13.2 metres (43.4 feet)
Max. Depth	43 metres (140 feet)
Volume	19.6 x $10^6 m^3$ (15,884 acre-feet)
Watershed Area	9.84 km^2 (3.80 square miles)
Flushing Rate	0.16 times per year

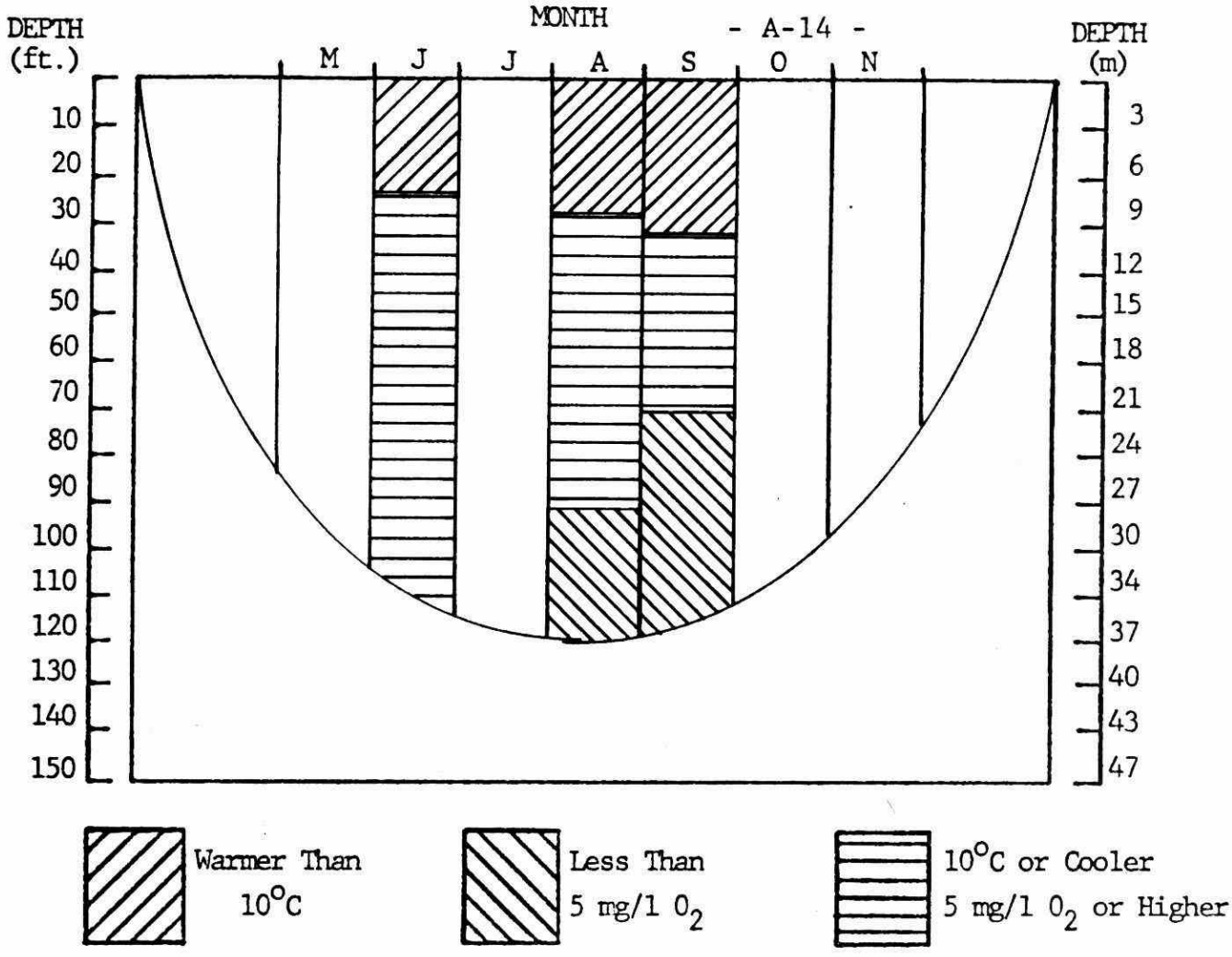
Shoreline Development

cottages, homes	1 MNR staff house & 5 cabins
vacant lots	0
tourist camps	0
tent, trailer sites	
% shoreline crown	90
% shoreline patent	10

Estimated Phosphorus Supply (Annual)

Upstream lakes	0		
Land runoff	45.6 kg	(100.2 lbs)	29%
Atmosphere	111.1 kg	(244.4 lbs)	70%
Shoreline Development	0.62 kg	(1.4 lbs)	1%
Sensitivity Index	77		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
8.0	26.2	1.7	3	26	58	9	283	0.08	7.3-7.6



Burns Lake

The 1978 survey of Burns Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles of Burns Lake (illustrated above) indicate good lake trout habitat.

Burns Lake supports an existing cottage density of one unit per 14.3 hectares (35.4 acres) of lake surface area. Development of the registered vacant lots would increase the cottage density to one unit for each 11.0 hectares (27.2 acres) of surface area.

Based on information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Due to the lake's low flushing rate, moderate depth and volume of bottom water, it is considered to be moderately susceptible to oxygen depletion.

It is concluded that additional shoreline development on Burns Lake could affect both the lake's surface water quality and the oxygen resource.

Burns Lake

Location: Renfrew County
Griffith Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	143 hectares (354 acres)
Mean Depth	11.3 metres (37.1 feet)
Max. Depth	36.6 metres (120 feet)
Volume	16.1 $x_2 10^6 m^3$ (13,052 acre-feet)
Watershed Area	7.1 km^2 (2.7 square miles)
Flushing Rate	0.1 times per year

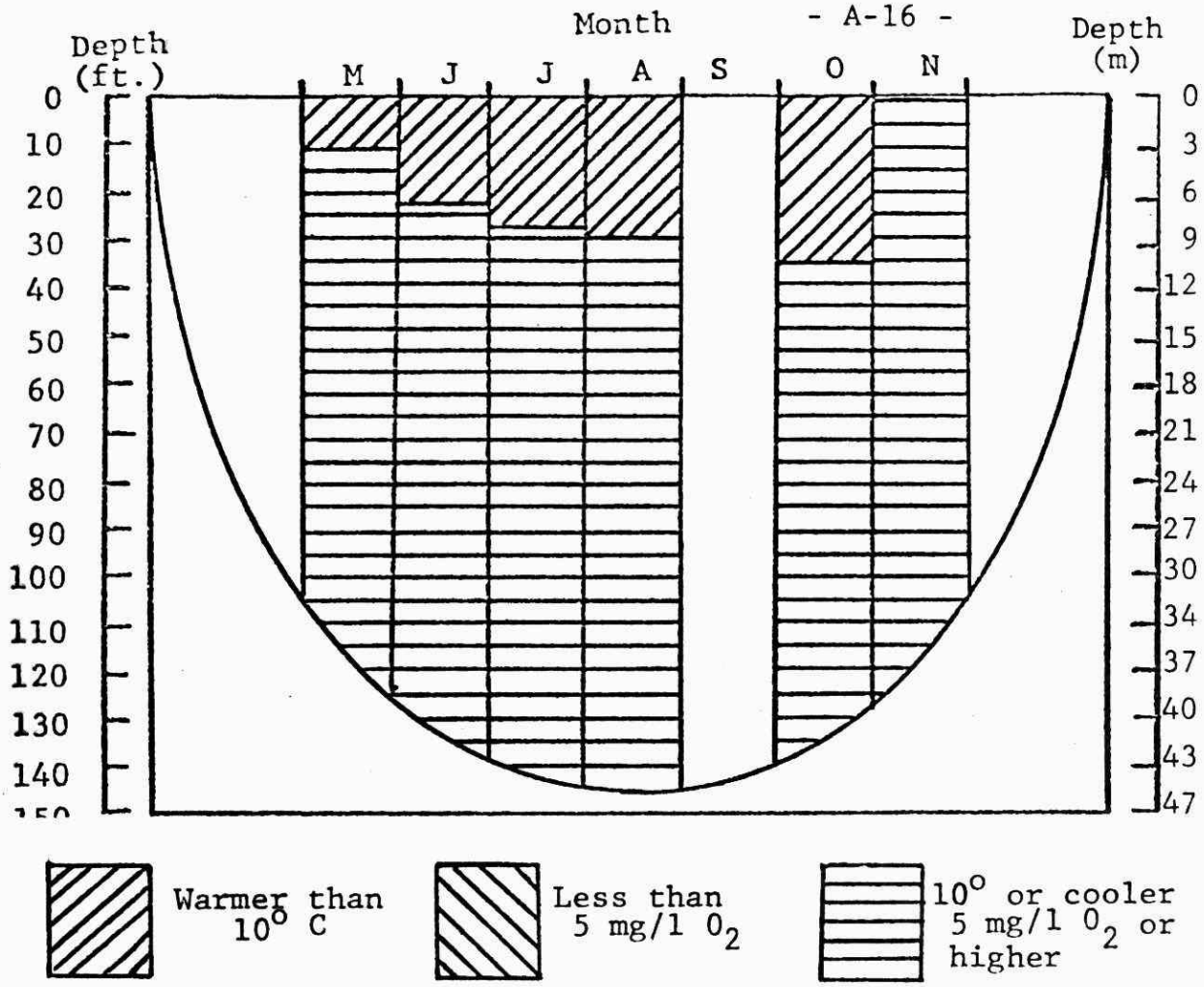
Shoreline Development

cottages, homes	10
vacant lots	3
tourist camps	0
tent, trailer sites	0
% shoreline crown	50
% shoreline patent	50

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	31.3 kg	(68.9 lbs)	22%
Atmosphere	107.2 kg	(235.8 lbs)	74%
Shoreline Development	6.2 kg	(13.6 lbs)	4%
Sensitivity Index	83		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.7	22	1.3	4	50	82	18	352	.05	7.5-7.9



Carson Lake

The 1977 survey of Carson Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Carson Lake (illustrated above) indicate excellent lake trout habitat. The entire water column contains oxygen conditions suitable for lake trout.

Carson Lake supports an existing cottage density of one unit for each 3.4 hectares (8.5 acres) of lake surface area. Development of the registered vacant lots would increase the cottage density to one unit for each 2.5 hectares (6.1 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. Similarly, because of the lake's large depth and volume of bottom water, its oxygen resource is considered to have a low susceptibility to depletion.

It is concluded that the effect of further shoreline development on Carson Lake would be limited to a potential slight decline in water clarity which would not significantly affect the lake's recreational use potential.

Carson Lake

Location: Renfrew County
Jones Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	273.2 hectares (675 acres)
Mean Depth	12.3 metres (40.4 feet)
Max. Depth	44.5 metres (146 feet)
Volume	33.5 x $10^6 m^3$ (27,160 acre-feet)
Watershed Area	25.9 km^2 (10 square miles)
Flushing Rate	0.25 times per year

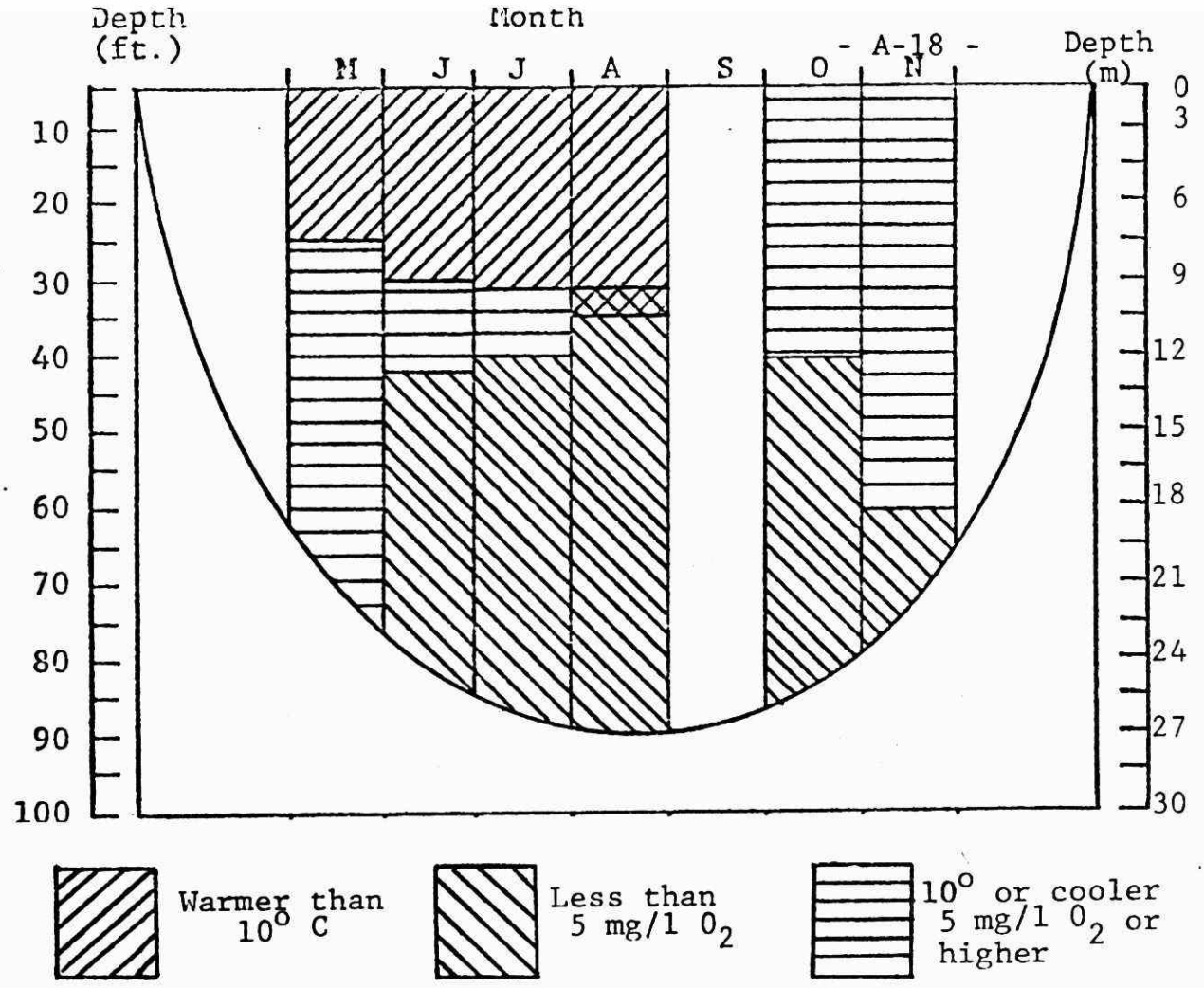
Shoreline Development

cottages, homes	79
vacant lots	31
tourist camps	2
tent, trailer sites	16
% shoreline crown	30
% shoreline patent	70

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil	
Land runoff	127.9 kg (282 lbs)	34%
Atmosphere	136.0 kg (300 lbs)	36%
Shoreline Development	111.1 kg (245 lbs)	30%
Sensitivity Index	30	

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.0	19.7	1.1	8	14	40	10	201	0.08	6.7-7.9



Cashel Lake

The 1977 survey of Cashel Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity and corresponding high degree of water clarity.

The temperature and oxygen profiles of Cashel Lake (illustrated above) indicate poor lake trout habitat. Extensive oxygen depletion is evident early in the summer and stress conditions appear evident by late summer.

Cashel Lake supports an existing cottage density of one unit for each 4.0 hectares (9.9 acres) of lake surface area. Development of the registered vacant lots would increase the cottage density to one unit for each 3.8 hectares (9.4 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. Similarly, owing to the lake's shallow nature and relatively small volume of bottom water, its oxygen resource is considered to be highly susceptible to further depletion.

It is concluded that further shoreline development on Cashel Lake could cause a significant increase in algal production and depletion of the lake's oxygen resource.

Cashel Lake

Location: Hastings County
Tudor and Cashel Townships

Watershed: Trent River

Morphometry Hydrology

Surface Area	167.9 hectares (415 acres)
Mean Depth	7.8 metres (25.6 feet)
Max. Depth	27.4 metres (90 feet)
Volume	13.1 x $10^6 m^3$ (10,620 acre-feet)
Watershed Area	28.5 km^2 (11 square miles)
Flushing Rate	0.3 times per year

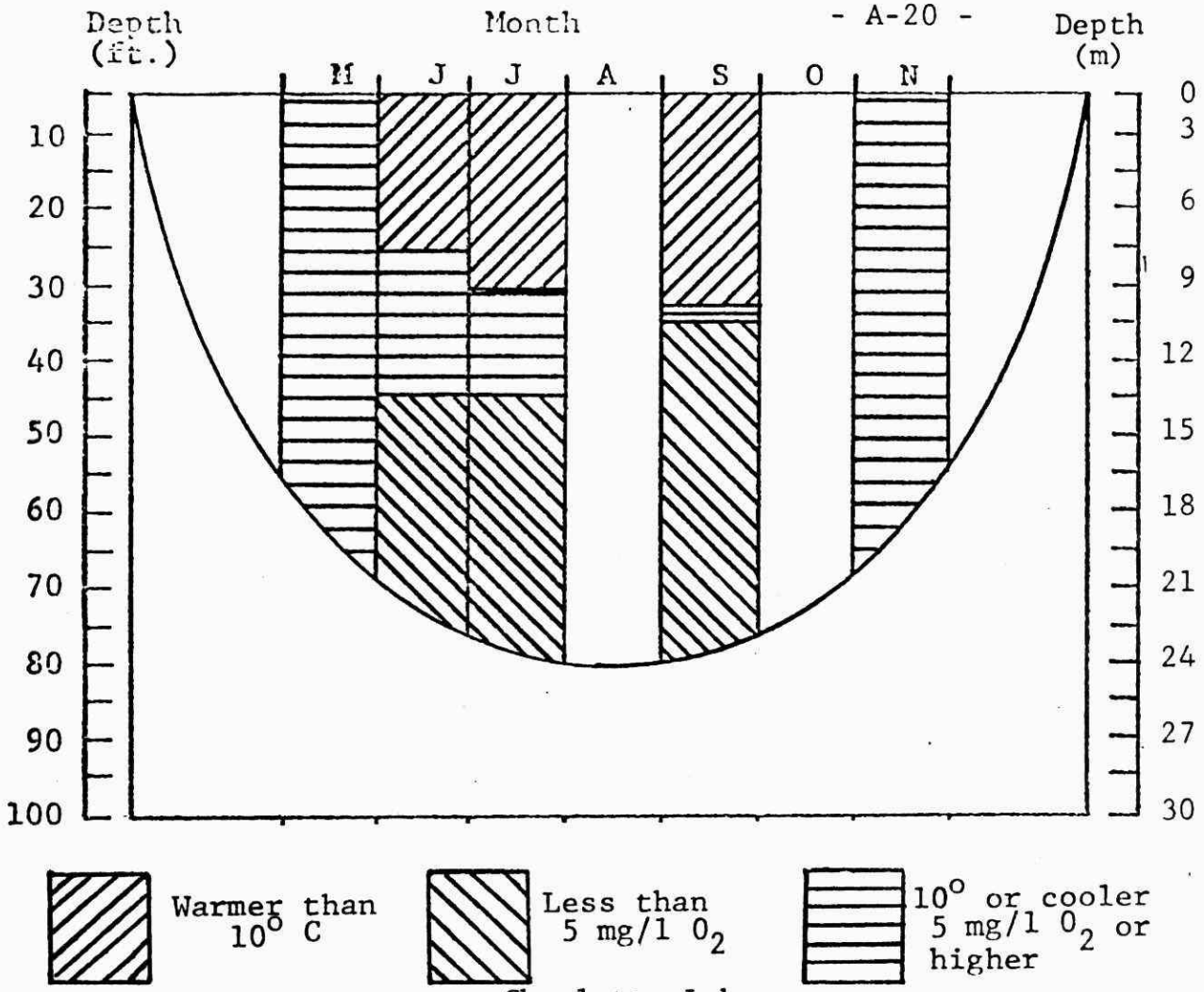
Shoreline Development

cottages, homes	42
vacant lots	2
tourist camps	0
tent, trailer sites	0
% shoreline crown	82
% shoreline patent	18

Estimated Phosphorus Supply (Annual)

Upstream lakes	78.2 kg	(172 lbs)	26%
Land runoff	104.1 kg	(229 lbs)	35%
Atmosphere	84.1 kg	(185 lbs)	28%
Shoreline Development	33.2 kg	(73 lbs)	11%
Sensitivity Index	64		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.3	17.4	1.2	5	111	132	19	320	0.07	7.8-8.2



Charlotte Lake

The 1976 survey of Charlotte Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Charlotte Lake (illustrated above) indicate only marginally suitable lake trout habitat. By September, serious oxygen depletion results in a very confined zone of suitable lake trout habitat.

Charlotte Lake supports an existing cottage density of one unit for each 4.4 hectares (11.0 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 2.6 hectares (6.5 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Similarly, because of the lake's shallow depth and small volume of bottom water, its oxygen resource is considered to be highly susceptible to further depletion.

It is concluded that further shoreline development on Charlotte Lake could cause a significant increase in algal production and further depletion of the oxygen resource.

Charlotte Lake

Location: Renfrew County
Brudenell Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	116.1 hectares (287 feet)
Mean Depth	7.4 metres (24.3 feet)
Max. Depth	23.8 metres (78 feet)
Volume	8.6 x $10^6 m^3$ (6,988 acre-feet)
Watershed Area	6.0 km^2 (2.33 square miles)
Flushing Rate	0.23 times per year

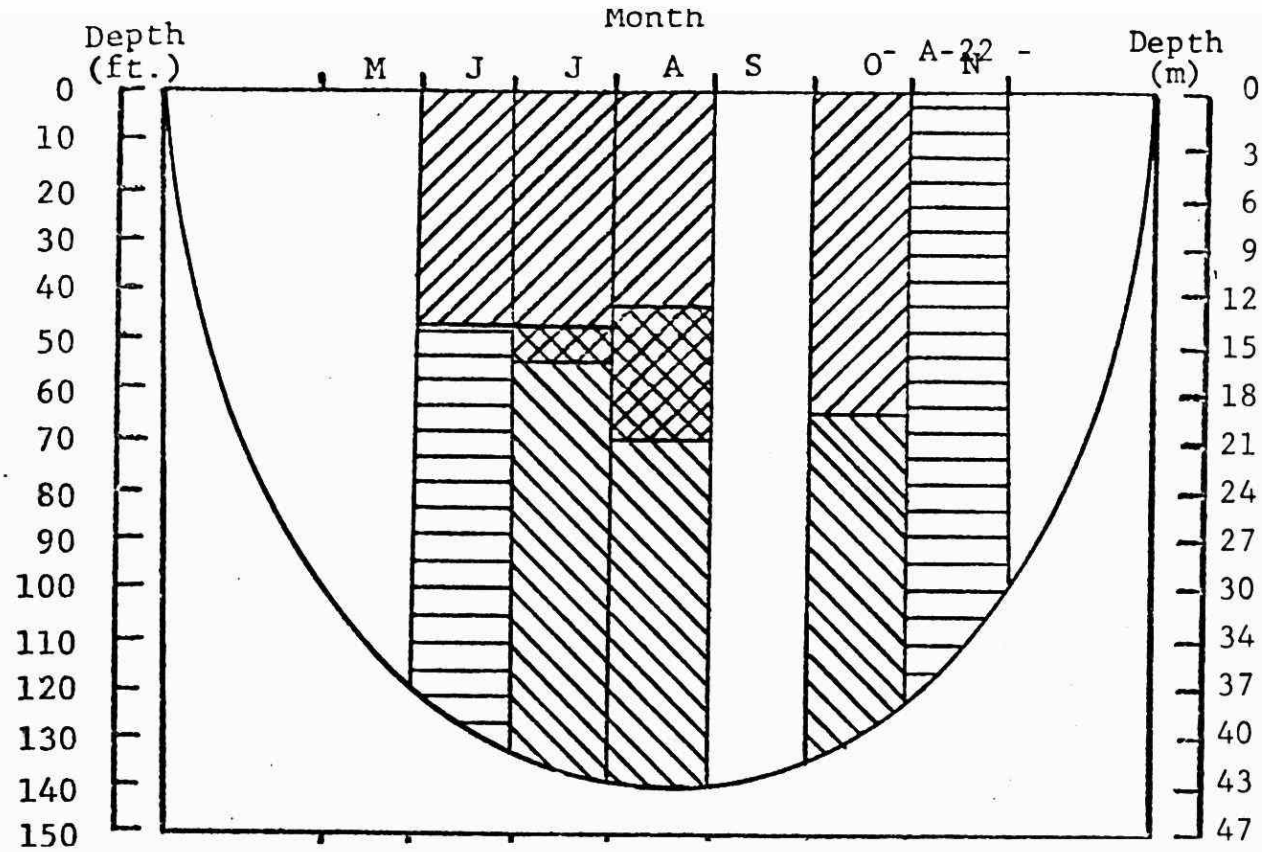
Shoreline Development

cottages, homes	26
vacant lots	18
tourist camps	0
tent, trailer sites	0
% shoreline crown	40
% shoreline patent	60

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	48.2 kg	(106 lbs)	35%
Atmosphere	86.8 kg	(191 lbs)	58%
Shoreline Development	15.9 kg	(35 lbs)	11%
Sensitivity Index	111		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.9	22.6	1.4	10	77	107	17	335	0.08	7.4-8.0



Clear Lake

The 1976, 1977 and 1978 surveys of Clear Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Clear Lake (illustrated above) indicate poor lake trout habitat. Warming of surface water to an atypical depth and extensive oxygen depletion appear to result in stress conditions for lake trout as early as July. The 1976 and 1978 profiles of Clear Lake (not illustrated) were similar to those shown for 1977.

Clear Lake supports an existing cottage density of one unit for each 7.1 hectares (17.6 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 5.6 hectares (13.9 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal density, decreased water clarity) is considered to be low. While the lake is relatively deep, the excessive depth of warm water confines the potential usable lake trout habitat to a small volume of water at the bottom of the lake. This small volume is highly susceptible to oxygen depletion.

It is concluded that further shoreline development on Clear Lake would not cause a significant increase in algal production and should therefore not result in further significant oxygen depletion.

Clear Lake

Location: Renfrew County
Sebastopol Township

Watershed: Bonnechere River

Morphometry Hydrology

Surface Area	1730.1 hectares (4275 acres)
Mean Depth	11.2 metres (36.7 feet)
Max. Depth	56.6 metres (140 feet)
Volume	194.0 x $10^6 m^3$ (157,280 acre-feet)
Watershed Area	94.3 km^2 (36.4 square miles)
Flushing Rate	0.2 times per year

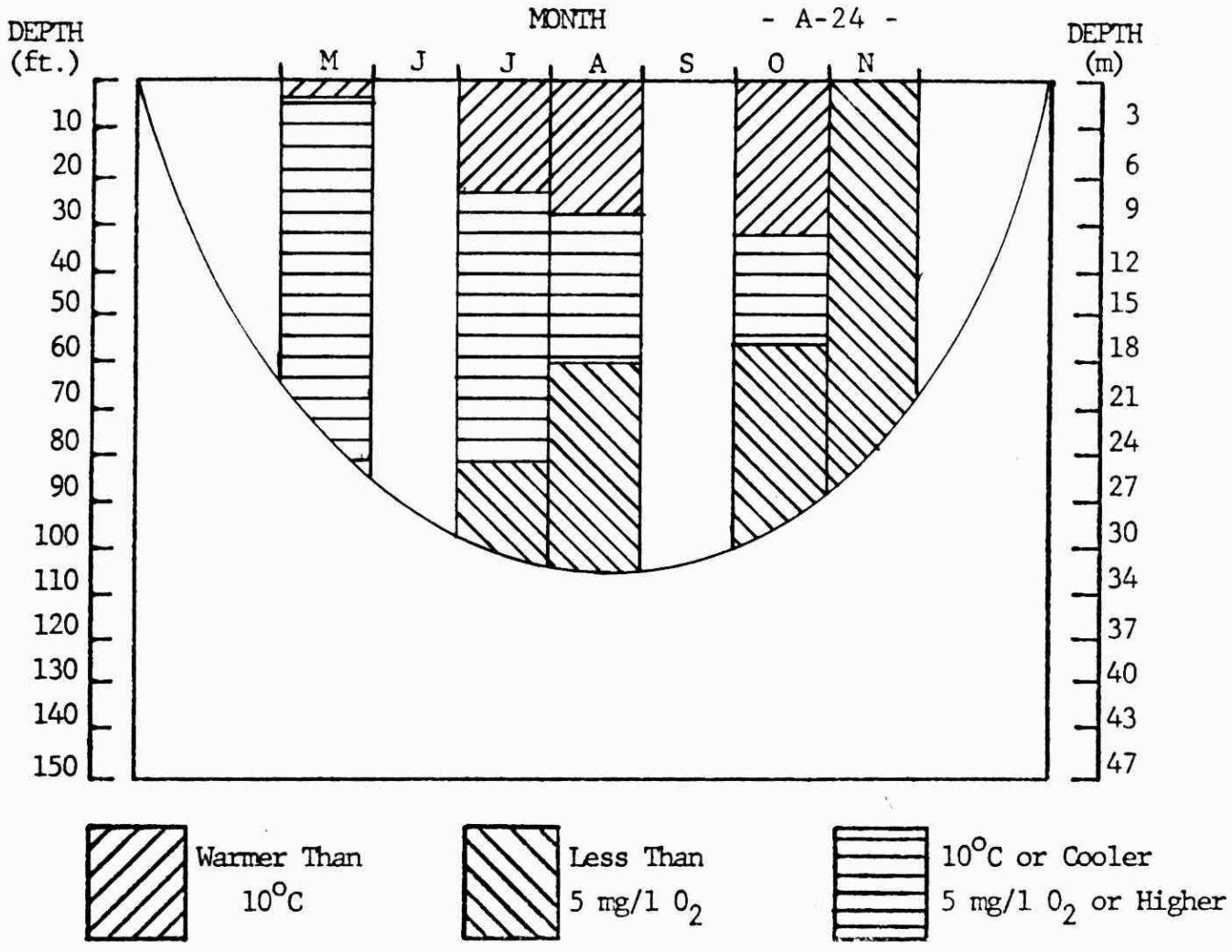
Shoreline Development

cottages, homes	242
vacant lots	65
tourist camps	2
tent, trailer sites	161
% shoreline crown	0
% shoreline patent	100

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	928.1 kg	(2042 lbs)	46%
Atmosphere	866.8 kg	(1907 lbs)	43%
Shoreline Development	218.6 kg	(481 lbs)	11%
Sensitivity Index	2		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
4.0	13.1	1.9	8	96	127	16	267	0.03	7.3-8.9



Colton Lake

The 1978 survey of Colton Lake revealed excellent water quality for recreational purposes. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles for Colton Lake (illustrated above) show good lake trout habitat. In October there remained 8.0 metres (26 feet) of suitable lake trout habitat.

Colton Lake supports an existing cottage density of one unit per 0.7 hectares (1.8 acres) of lake surface area. Development of the registered vacant lots would increase the cottage density to one unit per 0.6 hectares (1.5 acres).

Referring to Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Similarly, since the lake is of moderate depth and small volume; it is considered to be moderately susceptible to oxygen depletion.

It is concluded that addtiional shoreline development on Colton Lake could cause a significant increase in algal production and depletion of the lake's oxygen resource.

Colton Lake

Location: Renfrew County
Admaston Township

Watershed: Bonnechere River

Morphometry Hydrology

Surface Area	62 hectares (154 acres)
Mean Depth	9.7 metres (31.8 feet)
Max. Depth	32 metres (106 feet)
Volume	6.02 x $10^6 m^3$ (4,897 acre-feet)
Watershed Area	12.6 km^2 (4.9 square miles)
Flushing Rate	0.7 times per year

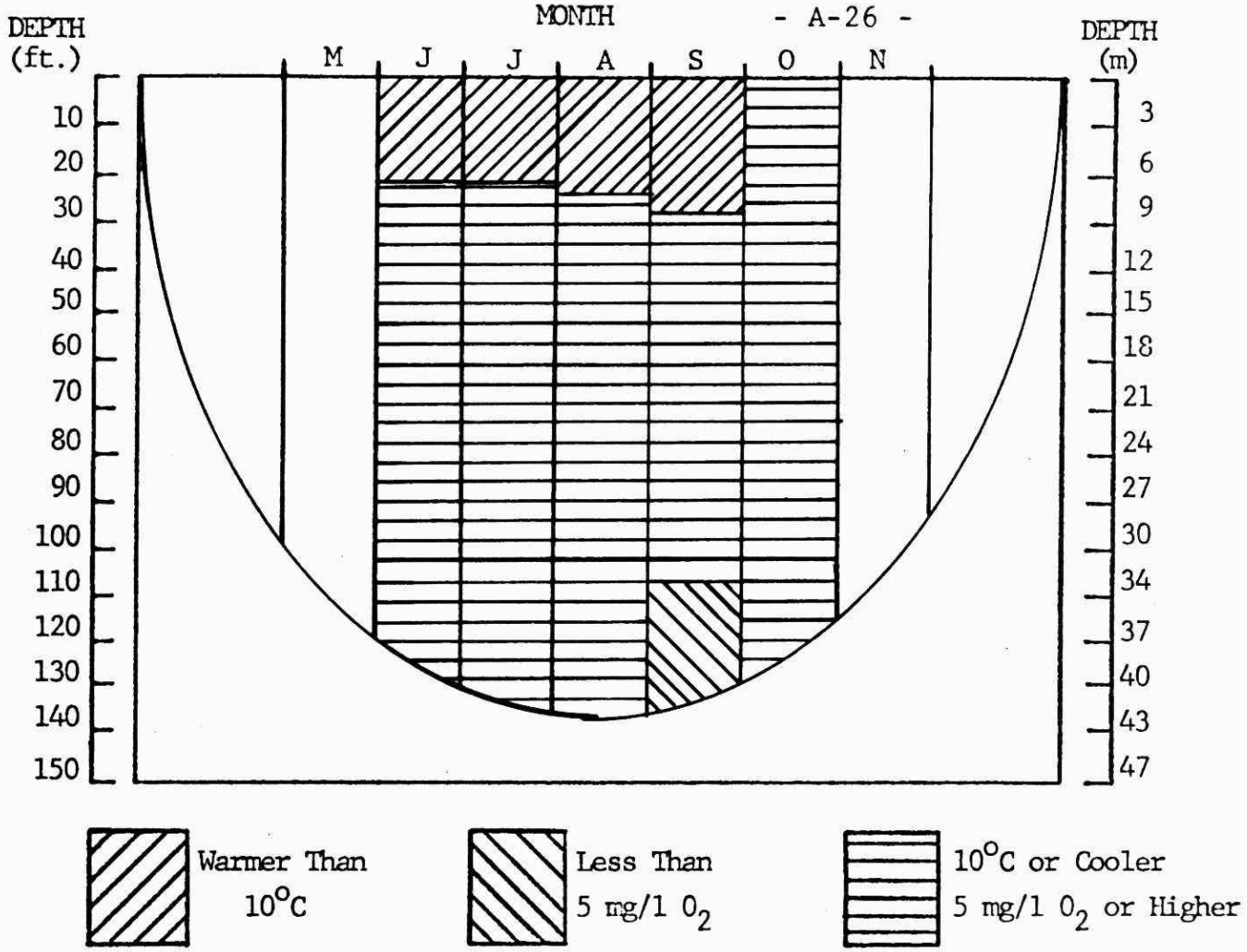
Shoreline Development

cottages, homes	84, 3
vacant lots	17
tourist camps	0
tent, trailer sites	0
% shoreline crown	0
% shoreline patent	100

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	65.9 kg	(145.0 lbs)	38%
Atmosphere	46.5 kg	(102.3 lbs)	27%
Shoreline Development	61.0 kg	(134.2 lbs)	35%
Sensitivity Index	185		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.1	16.7	1.4	9	138	165	10	330	.07	8.0-8.2



Cross (Lyell) Lake

The 1978 survey of Cross Lake revealed excellent water quality for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles of Cross Lake (illustrated above) indicate excellent water quality conditions for lake trout throughout the season.

Cross Lake supports an existing cottage density of one unit per 4.6 hectares (11.3 acres).

Based on the information presented in Table 1, the potential of further shoreline development affecting the surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. Since the oxygen resource is excellent and the deep water volume is substantial; the oxygen susceptibility to depletion is considered to be low.

It is concluded that further shoreline development may cause a slight increase in algal densities and hence a decrease in surface water quality however the deep water oxygen resource should not be affected.

Cross (Lyell) Lake

Location: District of Nipissing
Lyell Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	202 hectares (500 acres)
Mean Depth	10.6 metres (34.8 feet)
Max. Depth	47.1 metres (138 feet)
Volume	21.4 x $10^6 m^3$ (17,349 acre-feet)
Watershed Area	14.7 km^2 (5.68 square miles)
Flushing Rate	0.2 times per year

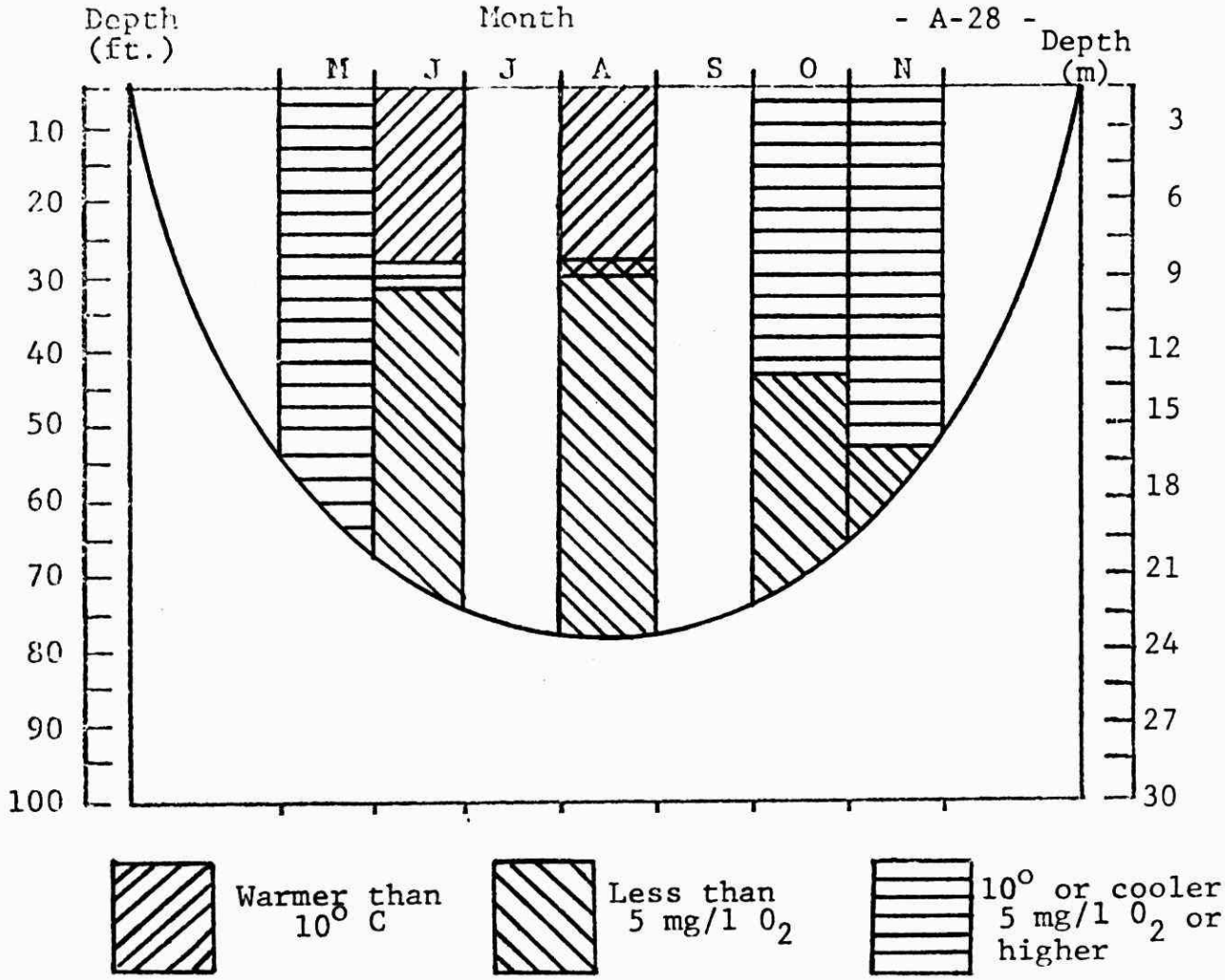
Shoreline Development

cottages, homes	44
vacant lots	information not available
tourist camps	0
tent, trailer sites	0
% shoreline crown	information not available
% shoreline patent	information not available

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	69.4 kg	(152.7 lbs)	27%
Atmosphere	156.8 kg	(345.0 lbs)	62%
Shoreline Development	27.1 kg	(59.6 lbs)	11%
Sensitivity Index	48		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
4.3	14.1	1.9	15	5	24	10	238	0.10	6.3-6.5



Diamond Lake (Herschel Township)

The 1977 survey of Diamond Lake (Herschel Township) revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Diamond Lake (illustrated above) indicate poor lake trout habitat. Extensive oxygen depletion was evident by July resulting in an extended period of stress conditions.

Diamond Lake supports an existing cottage density of one unit for each 1.9 hectares (4.6 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 1.3 hectares (3.3 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderately high. Similarly, owing to the lake's shallow nature and relatively small volume of bottom water, its oxygen resource is considered to be highly susceptible to further depletion.

It is concluded that further shoreline development on Diamond Lake (Herschel Township) could cause a significant increase in algal production and further depletion of the lake's oxygen resource.

Diamond Lake (Herschel Township)

Location: Hastings County
Herschel Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	150.1 hectares (371 acres)
Mean Depth	8.3 metres (27.2 feet)
Max. Depth	23.8 metres (78 feet)
Volume	12.3 x $10^6 m^3$ (10,120 acre-feet)
Watershed Area	32.6 km^2 (12.6 square miles)
Flushing Rate	0.9 times per year

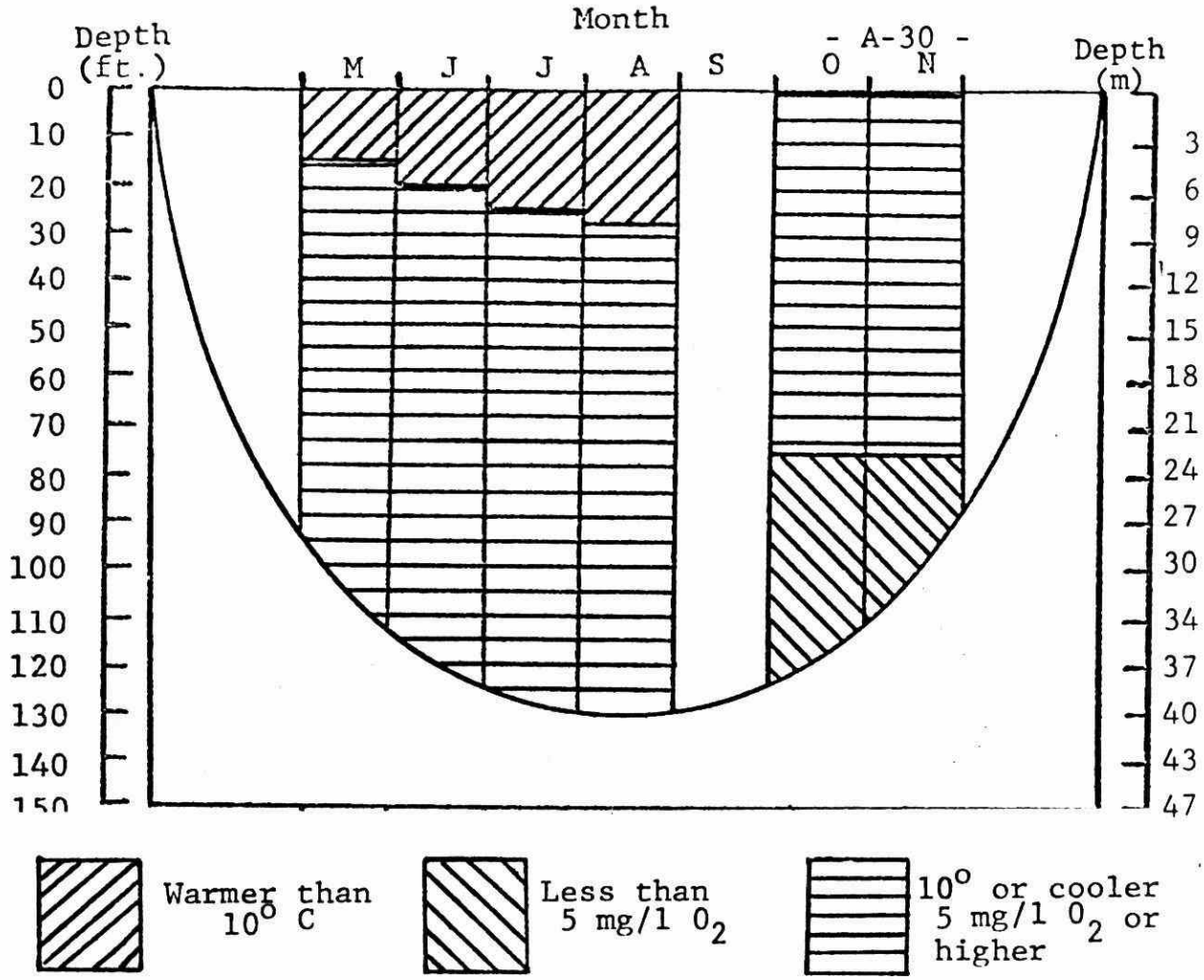
Shoreline Development

cottages, homes	81
vacant lots	31
tourist camps	1
tent, trailer sites	6
% shoreline crown	50
% shoreline patent	50

Estimated Phosphorus Supply (Annual)

Upstream lakes	79.1 kg	(174 lbs)	28%
Land runoff	35.0 kg	(77 lbs)	12%
Atmosphere	75.0 kg	(165 lbs)	27%
Shoreline Development	93.2 kg	(205 lbs)	33%
Sensitivity Index	50		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.4	17.1	1.1	10	21	48	10	248	0.12	6.3-7.3



Diamond Lake (Radcliffe Township)

The 1977 survey of Diamond Lake (Radcliffe Township) revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Diamond Lake (illustrated above) indicate excellent oxygen conditions for lake trout.

The existing cottage density on Diamond Lake is one unit for each 3.1 hectares (7.7 acres) of lake surface area. Development of the registered vacant lots would increase the cottage density to one unit for each 2.8 hectares (6.9 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal density, decreased water clarity) is considered to be high. Because of the lake's large depth and volume of bottom water, its oxygen resource is considered to have a low susceptibility to depletion.

It is concluded that additional shoreline development on Diamond Lake (Radcliffe Township) could result in a decline of water clarity but would not have a serious affect on the lake's oxygen resource.

Diamond Lake (Radcliffe Township)

Location: Renfrew County
Radcliffe Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	80.9 hectares (200 acres)
Mean Depth	13.8 metres (45.3 feet)
Max. Depth	39.6 metres (130 feet)
Volume	11.2 x $10^6 m^3$ (9,079 acre-feet)
Watershed Area	16.8 km^2 (6.5 square miles)
Flushing Rate	0.5 times per year

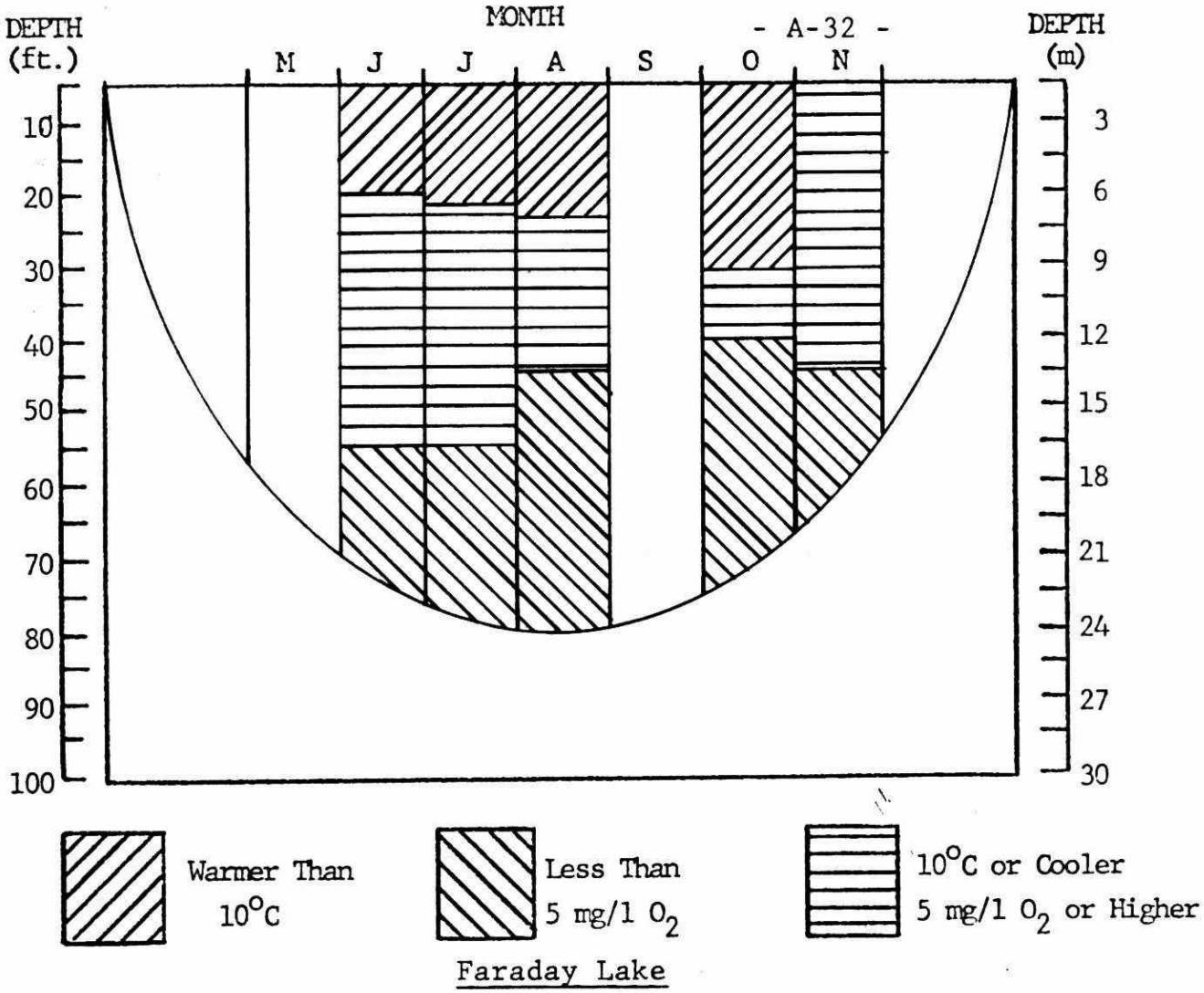
Shoreline Development

cottages, homes	26
vacant lots	3
tourist camps	0
tent, trailer sites	0
% shoreline crown	60
% shoreline patent	40

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	88.2 kg	(194 lbs)	61%
Atmosphere	40.0 kg	(88 lbs)	28%
Shoreline Development	15.9 kg	(35 lbs)	11%
Sensitivity Index	127		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.2	17.1	1.2	12	31	59	11	247	0.09	7.2-8.1


DEPTH (ft.)
MONTH
M J J A S O N
DEPTH (m)
10 20 30 40 50 60 70 80 90 100
3 6 9 12 15 18 21 24 27 30
Warmer Than 10°C
Less Than 5 mg/l O_2
10°C or Cooler
5 mg/l O_2 or Higher

Faraday Lake

The 1978 survey of Faraday Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles of Faraday Lake (illustrated above) indicate poor lake trout habitat. Less than 3.0 metres (10 feet) of suitable lake trout water remained in October.

Faraday Lake supports an existing cottage density of one unit per 1.3 hectares (3.1 acres) of lake surface area. Development of the registered vacant lots would increase the cottage density to one unit per 1.1 hectares (2.7 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Similarly, since the lake has a small volume of deep water and oxygen conditions are poor for lake trout; the oxygen resource is considered to be highly susceptible to depletion.

It is concluded that further shoreline devlopment could detrimentally affect both the surface water quality and the oxygen resource.

Faraday Lake

Location: Hastings County
Faraday Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	113 hectares (279 acres)
Mean Depth	9.0 metres (29.5 feet)
Max. Depth	24.4 metres (80 feet)
Volume	10.2 x $10^6 m^3$ (8227 acre-feet)
Watershed Area	19.2 km^2 (7.41 sqaure miles)
Flushing Rate	0.6 times per year

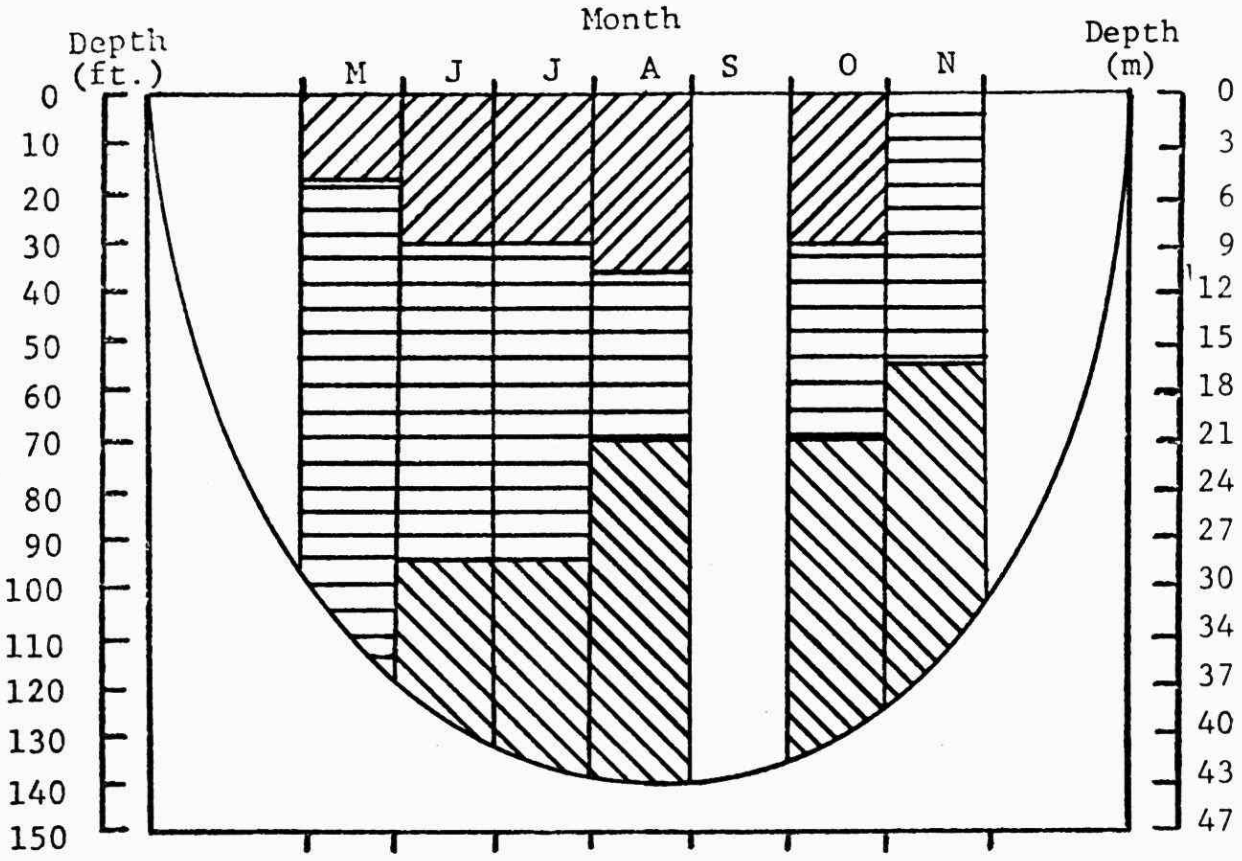
Shoreline Development

cottages, homes	89
vacant lots	13
tourist camps	1
tent, trailer sites	15
% shoreline crown	35
% shoreline patent	65

Estimated Phosphorus Supply (Annual)

Upstream lakes	11.0 kg	(24.2 lbs)	5%
Land runoff	74.9 kg	(164.8 lbs)	32%
Atmosphere	84.8 kg	(186.6 lbs)	37%
Shoreline Development	60.8 kg	(133.8 lbs)	26%
Sensitivity Index	85		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.0	19.7	1.4	7	14	35	7	257	0.08	6.6-7.1



Green Lake

The 1977 survey of Green Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Green Lake (illustrated above) indicate good to excellent lake trout habitat. Approximately 12.2 metres (40 feet) of the water column contained suitable oxygen conditions for lake trout.

Green Lake supports an existing cottage density of one unit for each 1.9 hectares (4.7 acres) of lake surface area. Development of the registered vacant lots would increase the cottage density to one unit for each 1.7 hectares (4.2 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal density, decreased water clarity) is considered to be high. The oxygen resource is considered to be moderately susceptible to depletion.

It is concluded that additional shoreline development on Green Lake could affect both the lake's water clarity and its oxygen resource.

Green Lake

Location: Renfrew County
Brougham Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	74.9 hectares (185 acres)
Mean Depth	16.8 metres (55 feet)
Max. Depth	42.7 metres (140 feet)
Volume	12.6 x $10^6 m^3$ (10,215 acre-feet)
Watershed Area	4.1 km^2 (1.6 square miles)
Flushing Rate	0.1 times per year

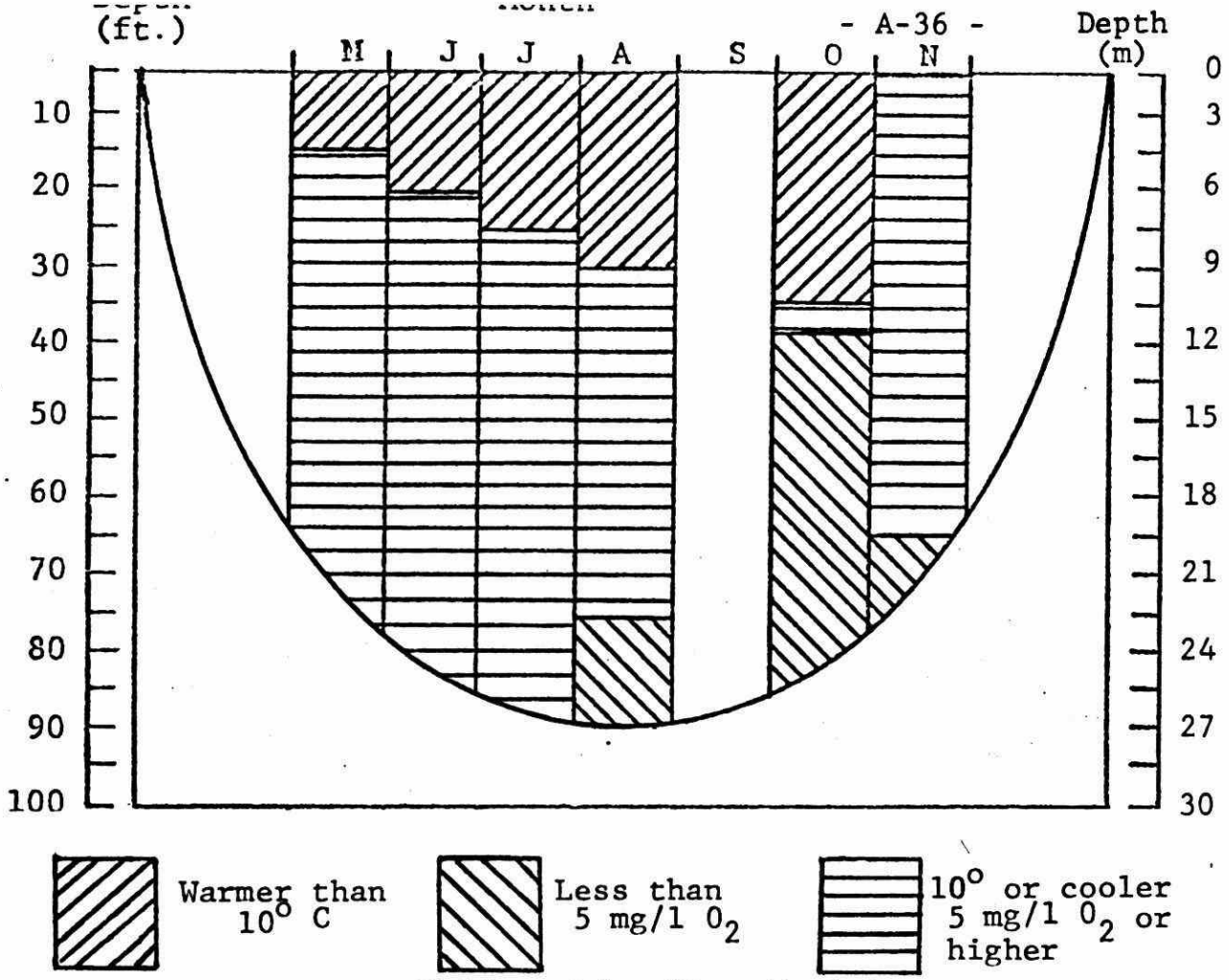
Shoreline Development

cottages, homes	39
vacant lots	5
tourist camps	0
tent, trailer sites	0
% shoreline crown	70
% shoreline patent	30

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	19.1 kg	(42 lbs)	23%
Atmosphere	38.2 kg	(84 lbs)	47%
Shoreline Development	24.1 kg	(53 lbs)	30%
Sensitivity Index	219		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
9.9	32.5	0.8	7	94	205	12	206	0.04	7.2-8.5



Halfway Lake (West Basin)

The 1977 survey of Halfway Lake (West Basin) revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Halfway Lake (West Basin) (as illustrated above) indicate good lake trout habitat throughout most of the season however oxygen depletion at the end of the summer stratification period was quite extensive.

Halfway Lake (West Basin) supports an existing cottage density of one unit for each 1.5 hectares (3.6 acres) of lake surface area.

Based on the information provided on Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal density, decreased water clarity) is considered to be low. While the lake is moderately shallow, its rapid flushing rate is considered to have a modifying influence on the susceptibility of the oxygen resource to further depletion. The lake's sensitivity to further oxygen depletion is considered to be moderate.

It is concluded that further shoreline development on Halfway Lake (West Basin) would have a slight potential to cause further oxygen depletion.

Halfway Lake (West Basin)

Location: Renfrew County
Radcliffe Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	95.9 hectares (237 acres)
Mean Depth	8.5 metres (27.9 feet)
Max. Depth	27.4 metres (90 feet)
Volume	8.2 x $10^6 m^3$ (6,650 acre-feet)
Watershed Area	163.2 km^2 (63 square miles)
Flushing Rate	7 times per year

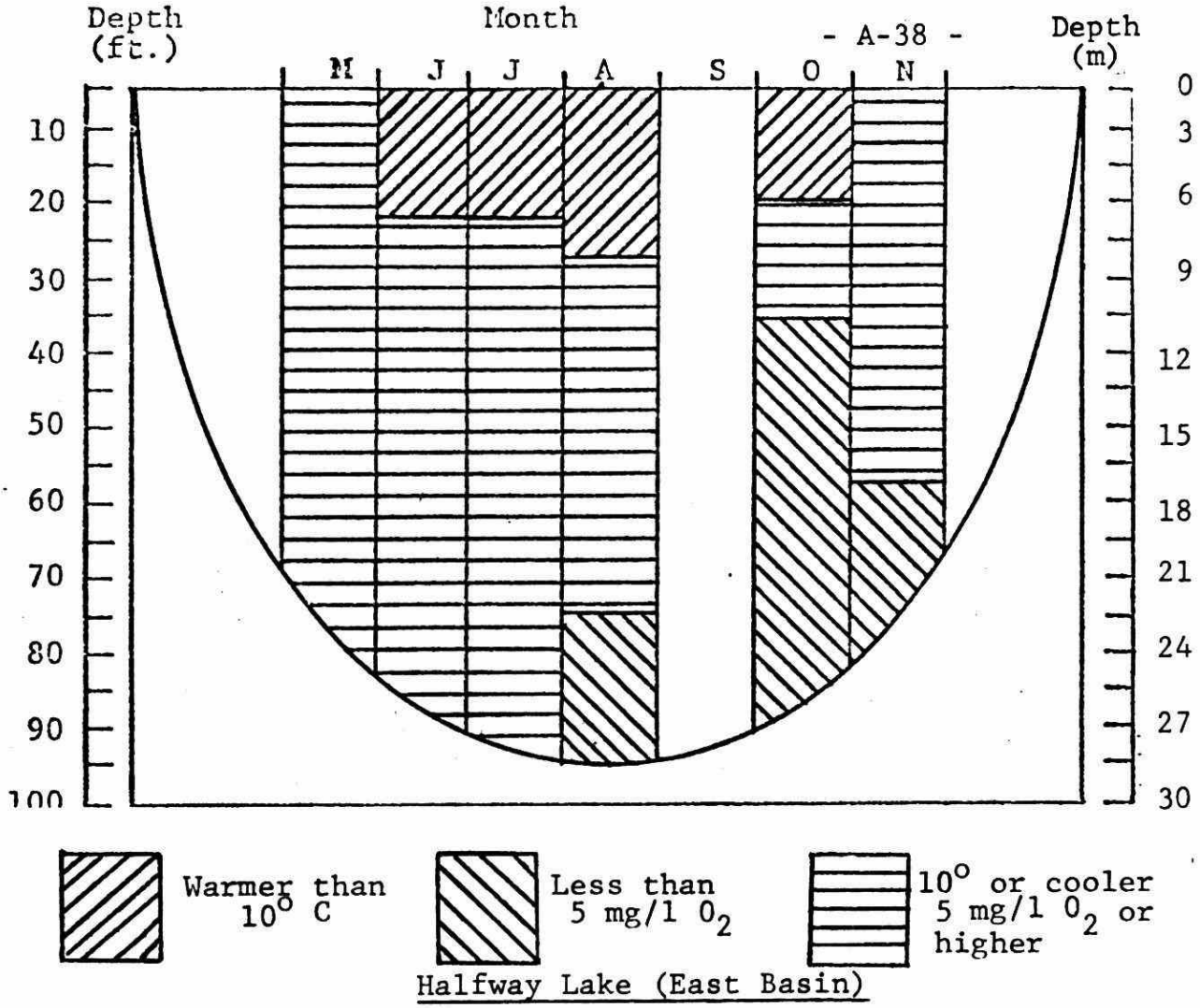
Shoreline Development

cottages, homes	65
vacant lots	1
tourist camps	1
tent, trailer sites	6
% shoreline crown	information not available
% shoreline patent	information not available

Estimated Phosphorus Supply (Annual)

Upstream lakes	831.8 kg	(1830 lbs)	88%
Land runoff	22.3 kg	(49 lbs)	2%
Atmosphere	47.7 kg	(105 lbs)	5%
Shoreline Development	49.1 kg	(108 lbs)	5%
Sensitivity Index	15		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.3	20.7	1.0	8	62	101	15	287	0.08	7.0-8.3



Halfway Lake (East Basin)

The 1977 survey of Halfway Lake (East Basin) revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Halfway Lake (East Basin) (as illustrated above) indicate good lake trout habitat exists throughout most of the season however oxygen depletion at the end of the summer stratification period was quite extensive.

Halfway Lake (East Basin) supports an existing cottage density of one unit for each 2.2 hectares (5.4 acres) of lake surface area. Development of registered vacant lots would increase the density to one unit for each 2.1 hectares (5.1 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. Similarly, considering the lake's depth and flushing rate, its oxygen resource is considered to have a moderate susceptibility to further depletion.

It is concluded that further shoreline development on Halfway Lake (East Basin) would have only a slight potential of causing further oxygen depletion.

Halfway Lake (East Basin)

Location: Renfrew County
Radcliffe Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	63.9 hectares (158 acres)
Mean Depth	11.8 metres (38.6 feet)
Max. Depth	29.3 metres (96 feet)
Volume	7.5 x $10^6 m^3$ (6,100 acre-feet)
Watershed Area	158 km^2 (61 square miles)
Flushing Rate	7.4 times per year

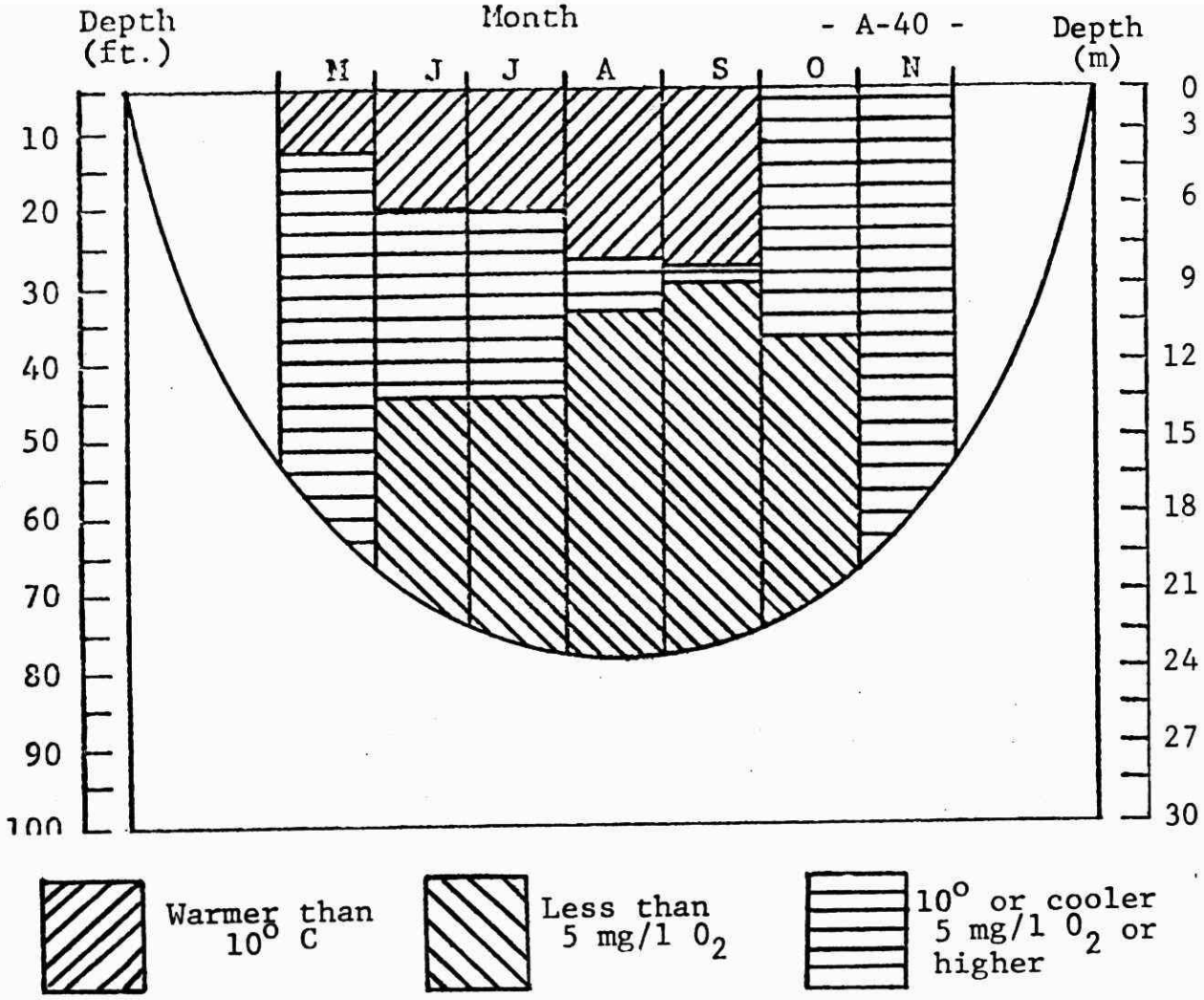
Shoreline Development

cottages, homes	29
vacant lots	2
tourist camps	3
tent, trailer sites	39
% shoreline crown	information not available
% shoreline patent	information not available

Estimated Phosphorus Supply (Annual)

Upstream lakes	772.7 kg	(1700 lbs)	85%
Land runoff	62.3 kg	(137 lbs)	7%
Atmosphere	32.3 kg	(71 lbs)	4%
Shoreline Development	40.0 kg	(88 lbs)	4%
Sensitivity Index	17		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.4	21	1.0	12	63	99	10	238	0.13	7.4-8.2



Jamieson Lake

The 1977 survey of Jamieson Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Jamieson Lake (illustrated above) indicate poor lake trout habitat. The usable lake trout water is highly confined during late summer and early fall.

Jamieson Lake supports an existing cottage density of one unit for each 2.8 hectares (7.0 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 2.3 hectares (5.4 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Considering the lake's shallow depth and small volume of bottom water, its oxygen resource is believed to be highly susceptible to further depletion.

It is concluded that further shoreline development on Jamieson Lake could cause a significant increase in algal production and further depletion of the lake's oxygen resource.

Jamieson Lake

Location: Hastings County
Dungannon Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	48.2 hectares (119 acres)
Mean Depth	8.5 metres (27.9 feet)
Max. Depth	23.8 metres (78 feet)
Volume	4.1 x $10^6 m^3$ (3,299 acre-feet)
Watershed Area	8.0 km^2 (3.1 square miles)
Flushing Rate	0.7 times per year

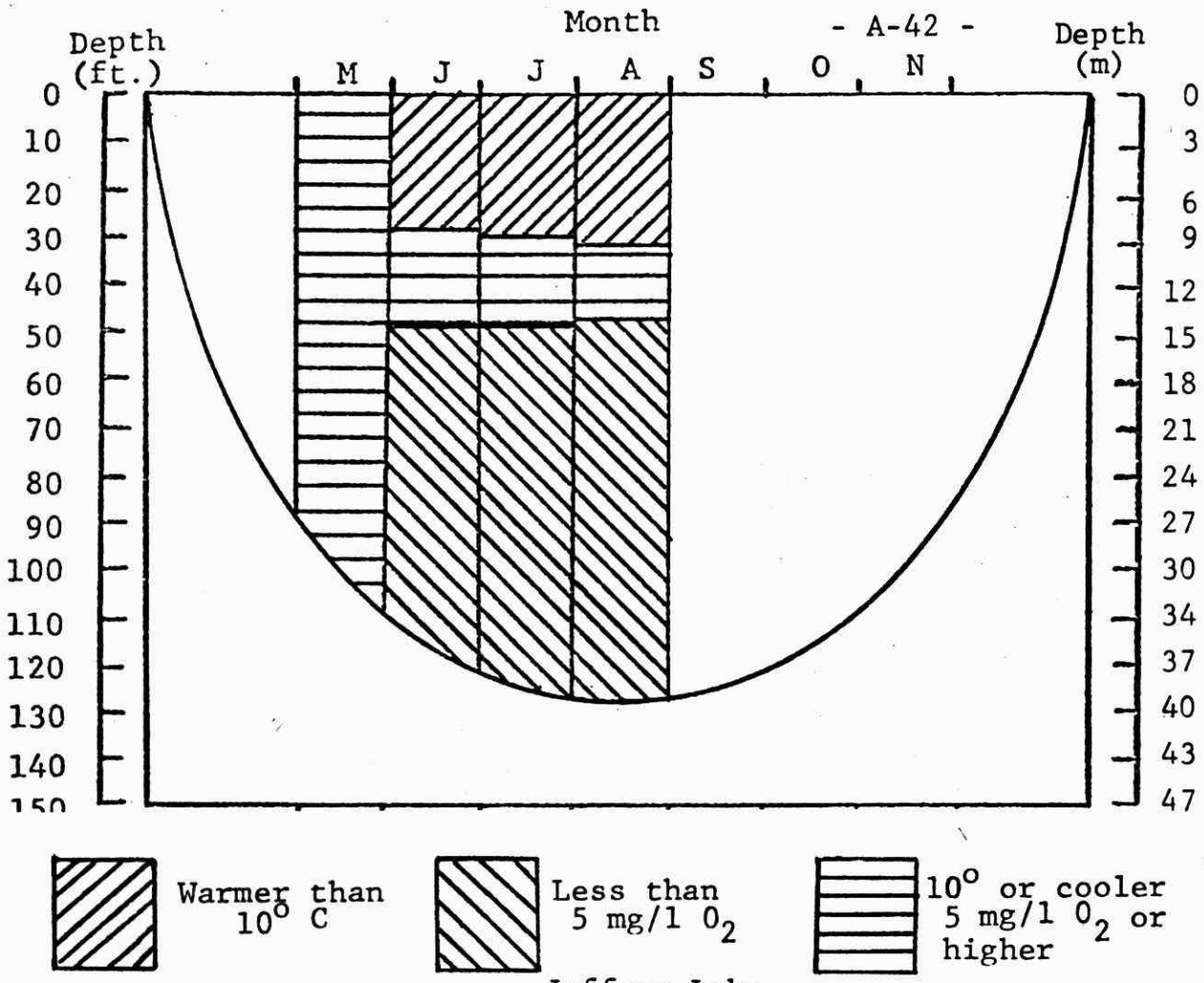
Shoreline Development

cottages, homes	17
vacant lots	5
tourist camps	0
tent, trailer sites	0
% shoreline crown	65
% shoreline patent	35

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	42.3 kg	(93 lbs)	50%
Atmosphere	24.1 kg	(53 lbs)	28%
Shoreline Development	18.2 kg	(40 lbs)	22%
Sensitivity Index	295		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.2	20.3	0.9	7	99	126	10	286	0.08	7.7-8.5



Jeffery Lake

The 1977 survey of Jeffery Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Jeffery Lake (illustrated above) indicate fair lake trout habitat. Suitable oxygen conditions for lake trout were confined to a narrow band of water high up the water column.

Jeffery Lake supports an existing cottage density of one unit for each 1.0 hectares (2.4 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 0.6 hectares (1.5 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. While the explanation for the existing degree of oxygen depletion is not readily apparent, the small volume of remaining usable lake trout habitat is considered to be highly susceptible to further depletion.

It is concluded that further shoreline development on Jeffery Lake could cause a significant increase in algal production and further depletion of the lake's oxygen resource.

Jeffery Lake

Location: Hastings County
Faraday Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	42.1 hectares (104 acres)
Mean Depth	12.5 metres (41 feet)
Max. Depth	38.7 meters (127 feet)
Volume	5.3 x $10^6 m^3$ (4,260 acre-feet)
Watershed Area	3.7 km^2 (1.43 square miles)
Flushing Rate	0.2 times per year

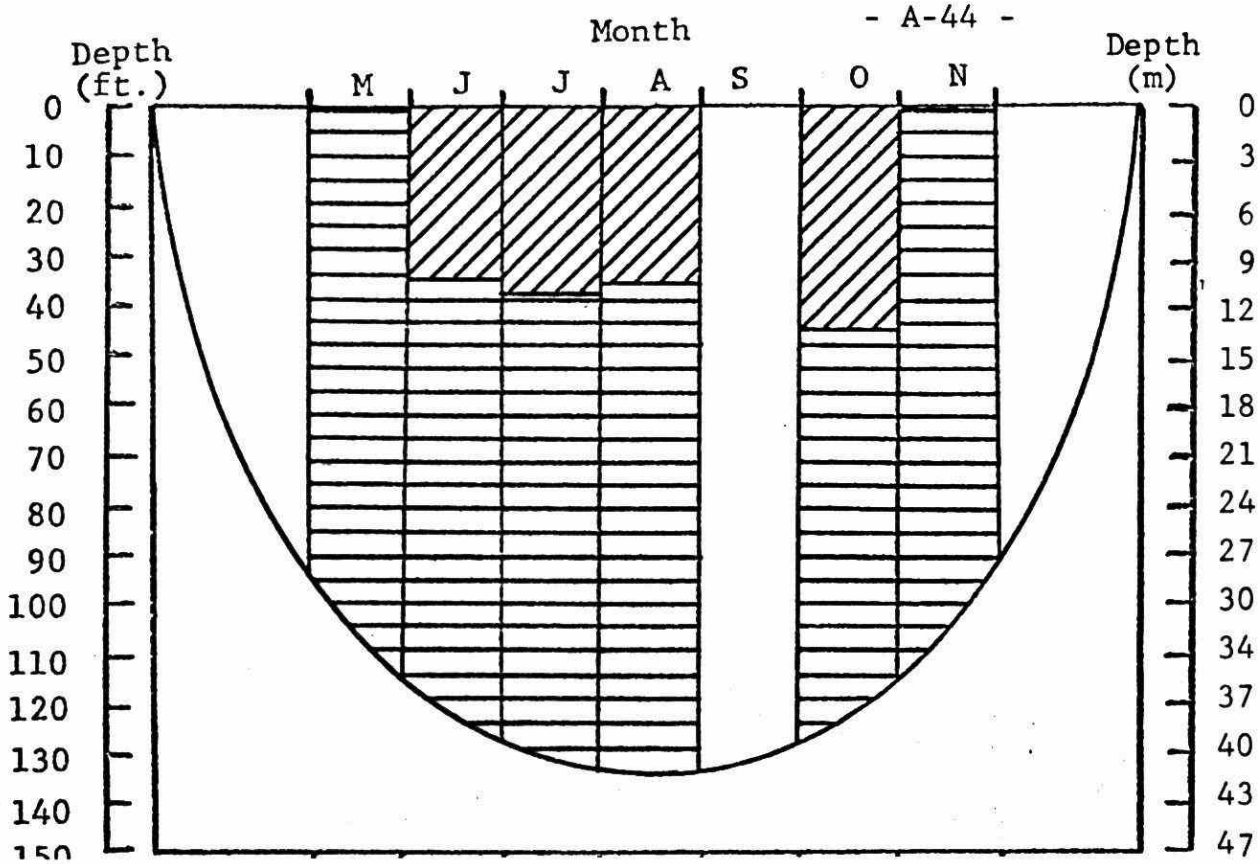
Shoreline Development

cottages, homes	44
vacant lots	23
tourist camps	0
tent, trailer sites	0
% shoreline crown	0
% shoreline patent	100

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	32.3 kg	(71 lbs)	39%
Atmosphere	20.9 kg	(46 lbs)	25%
Shoreline Development	29.1 kg	(64 lbs)	36%
Sensitivity Index	451		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
7.9	25.9	0.8	8	100	130	8	220	0.06	7.2-8.4



Kamaniskeg Lake (South Basin)

The 1977 and 1978 surveys of Kamaniskeg Lake (South Basin) revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Kamaniskeg Lake (South Basin) as illustrated above, indicate excellent lake trout habitat. The lake's entire water column contains oxygen conditions suitable for lake trout.

Kamaniskeg Lake supports an existing cottage density of one unit for each 6.2 hectares (15.3 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 4.3 hectares (10.7 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be low. Similarly, because of the lake's large depth, volume of bottom water and substantial flushing action, its oxygen resource is considered to have a low susceptibility to depletion.

It is concluded that further shoreline development on Kaminiskeg Lake (South Basin) would have little effect on water quality conditions.

Kamaniskeg Lake (South Basin)

Location: Renfrew County
Sherwood Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	1295.0 hectares (3200 acres)
Mean Depth	13.4 metres (43.8 feet)
Max. Depth	40.5 metres (133 feet)
Volume	173.9 x $10^6 m^3$ (141,000 acre-feet)
Watershed Area	2934.5 km^2 (1133 square miles)
Flushing Rate	5.9 times per year

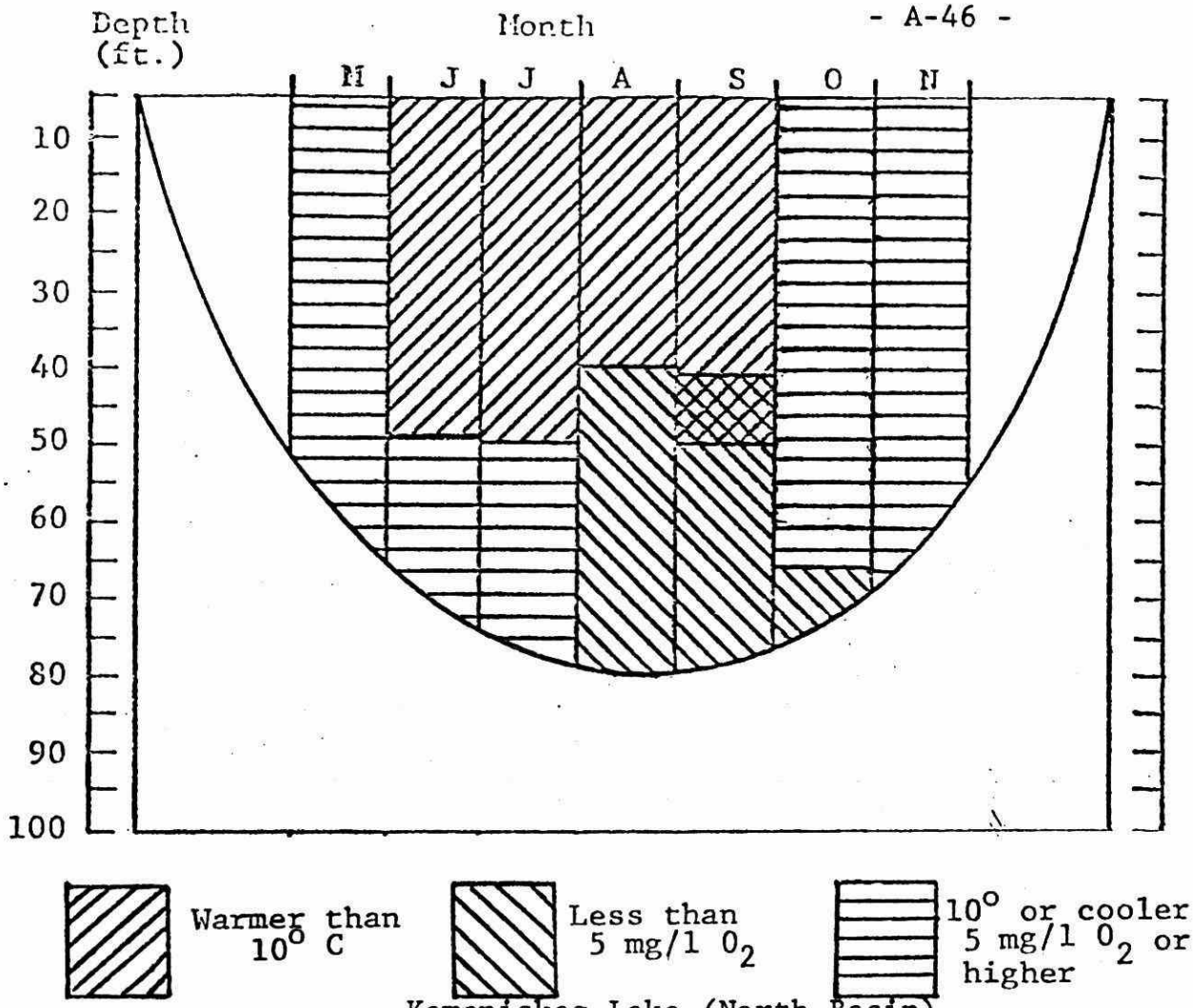
Shoreline Development

cottages, homes	210
vacant lots	88
tourist camps	2
tent, trailer sites	38
% shoreline crown	information not available
% shoreline patent	information not available

Estimated Phosphorus Supply (Annual)

Upstream lakes	11423.2 kg	(25,131 lbs)	91%
Land runoff	440.9 kg	(970 lbs)	3%
Atmosphere	646.8 kg	(1423 lbs)	5%
Shoreline Development	161.4 kg	(355 lbs)	1%
Sensitivity Index	0.2		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.4	17.7	1.2	5	9	32	7	216	0.10	6.4-7.2



Kamaniskeg Lake (North Basin)

The 1977 and 1978 survey of Kamaniskeg Lake (North Basin) revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Kamaniskeg Lake (North Basin) in 1977 as illustrated above, indicate poor lake trout habitat. Warming of the surface waters to an atypical depth and extensive oxygen depletion appear to result in stress conditions for lake trout by August. The 1978 survey indicated conditions had improved to the good category described in Table 2.

Kamaniskeg Lake (North Basin) supports an existing cottage density of one unit for each 6.0 hectares (14.8 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 4.6 hectares (11.3 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be low. Because of the lake's shallow nature and atypically warm surface waters, its oxygen resource is considered to be highly susceptible to depletion.

It is concluded that further shoreline development on Kamaniskeg Lake (North Basin) would not cause a significant increase in algal production and should therefore not result in significant further oxygen depletion.

Kamaniskeg Lake (North Basin)

Location: Renfrew County
Sherwood Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	924.3 hectares (2284 acres)
Mean Depth	8.8 metres (29 feet)
Max. Depth	25.6 metres (84 feet)
Volume	81.8 x $10^6 m^3$ (66,300 acre-feet)
Watershed Area	116.9 km^2 (45.14 square miles)
Flushing Rate	0.27 times per year

Shoreline Development

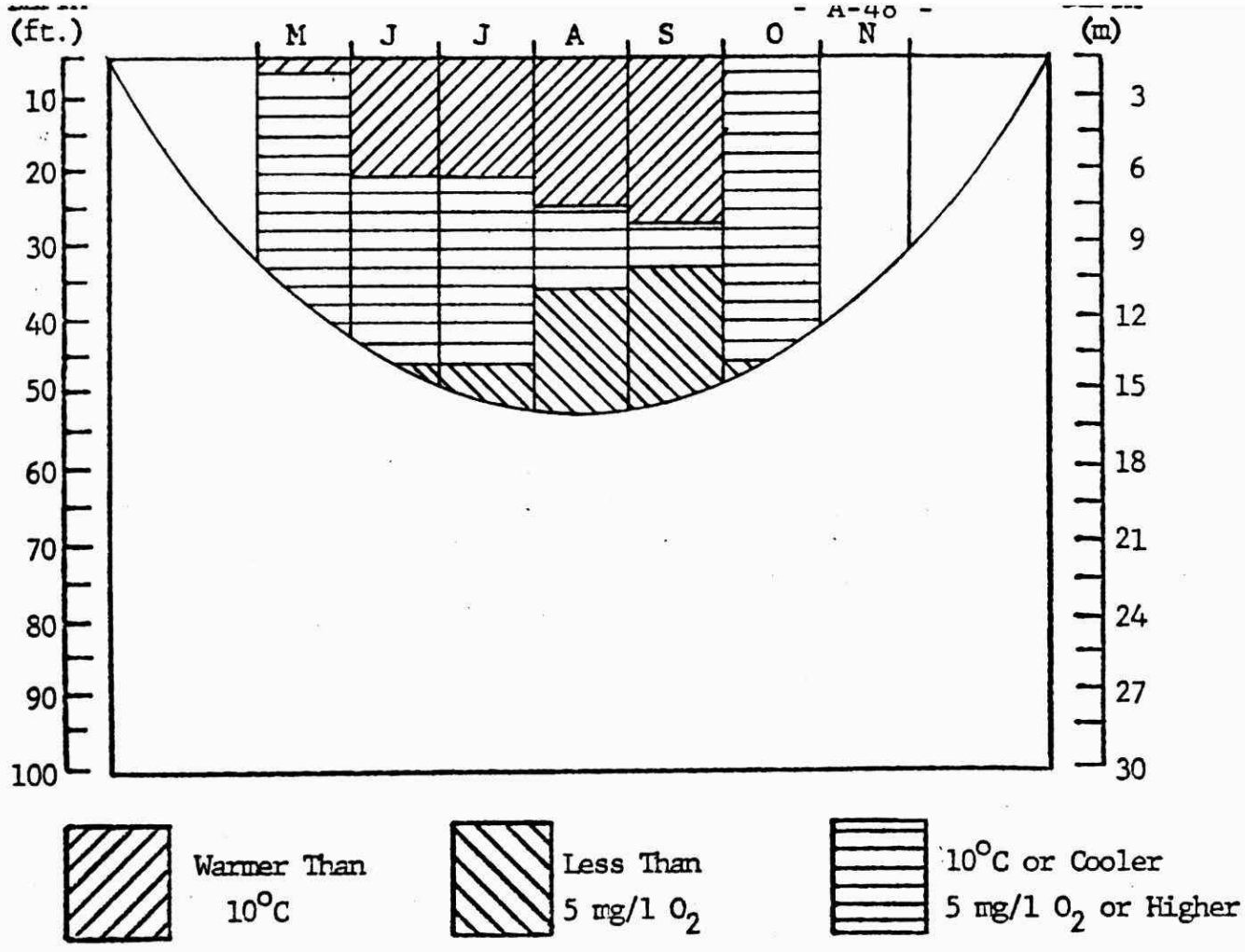
cottages, homes	154
vacant lots	48
tourist camps	3
tent, trailer sites	10
% shoreline crown	information not available
% shoreline patent	information not available

Estimated Phosphorus Supply (Annual)

Upstream lakes	168.6 kg	(371 lbs)	9%
Land runoff	595.4 kg	(1310 lbs)	32%
Atmosphere	461.8 kg	(1016 lbs)	25%
Shoreline Development	622.7 kg	(1370 lbs)	34%*
Sensitivity Index	5		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
4.8	15.7	1.4	7	11	35	9	257	0.06	6.6-7.4

* includes an estimated input of 416 kg (915.2 lbs) from the Village of Barry's Bay Water Pollution Control Plant based on records for 1976.



Kulas (Greenan) Lake

The 1978 survey of Kulas (Greenan) Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles of Kulas Lake (illustrated above) indicate poor lake trout habitat. By September, serious oxygen depletion results in only 2.2 metres (7.2 feet) of remaining suitable water.

Kulas Lake supports an existing cottage density of one unit for each 4.3 hectares (10.6 acres) of lake surface area. Development of the registered vacant lots would mean a slight increase in the cottage density to one unit for each 3.9 hectares (9.6 acres).

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate.

Due to Kulas Lake's shallow depth and small deep water volume, the oxygen resource is highly susceptible to depletion. It is concluded further shoreline development on Kulas Lake could cause an increase in algal production and a further decrease in the oxygen resource.

Kulas (Greenan) Lake

Location: Renfrew County
Jones and Sherwood Townships

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	90 hectares (222 acres)
Mean Depth	8.1 metres (26.5 feet)
Max. Depth	16 metres (54 feet)
Volume	7.3 x $10^6 m^3$ (5,910 acre-feet)
Watershed Area	46.9 km^2 (18.1 square miles)
Flushing Rate	2.3 times per year

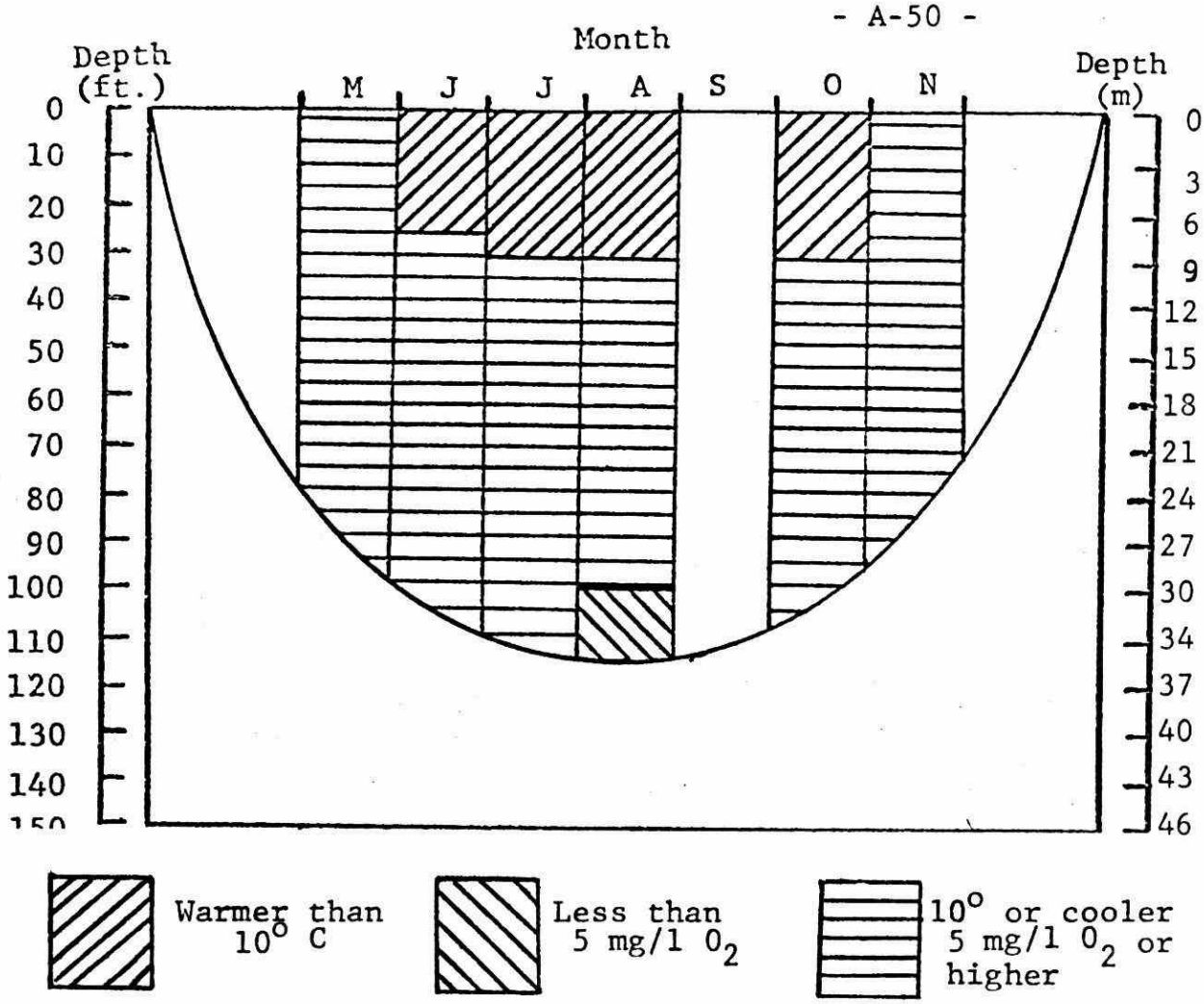
Shoreline Development

cottages, homes	20, 1
vacant lots	2
tourist camps	0
tent, trailer sites	0
% shoreline crown	5
% shoreline patent	95

Estimated Phosphorus Supply (Annual)

Upstream lakes	101.4 kg	(223.1 lbs)	54%
Land runoff	24.8 kg	(54.6 lbs)	13%
Atmosphere	45.0 kg	(99.0 lbs)	24%
Shoreline Development	15.4 kg	(33.9 lbs)	8%
Sensitivity Index	56		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.2	17.1	1.5	8	14	41	11.4	331	.09	6.8-7.2



L'Amable Lake

The 1977 survey of L'Amable Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of L'Amable (illustrated above) indicate excellent lake trout habitat. The entire water column contains suitable oxygen conditions for lake trout.

L'Amable Lake supports an existing cottage density of one unit for each 4.8 hectares (12 acres) of lake surface area. Development of all of the registered vacant lots on the lake would increase the cottage density to one unit for each 2.0 hectares (4.9 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. Based on the lake's large depth and volume of bottom water, its oxygen resource is considered to have a low susceptibility to depletion.

It is concluded that the effect of further shoreline development on L'Amable Lake would be limited to a potential slight decline in water clarity that would not affect the recreational use potential of the lake.

L'Amable Lake

Location: Hastings County
Faraday Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	179.3 kg (443 acres)
Mean Depth	19.6 metres (64.3 feet)
Max. Depth	35.1 metres (115 feet)
Volume	35.1 x $10^6 m^3$ (28,439 acre-feet)
Watershed Area	37.3 km^2 (14.4 square miles)
Flushing Rate	0.36 times per year

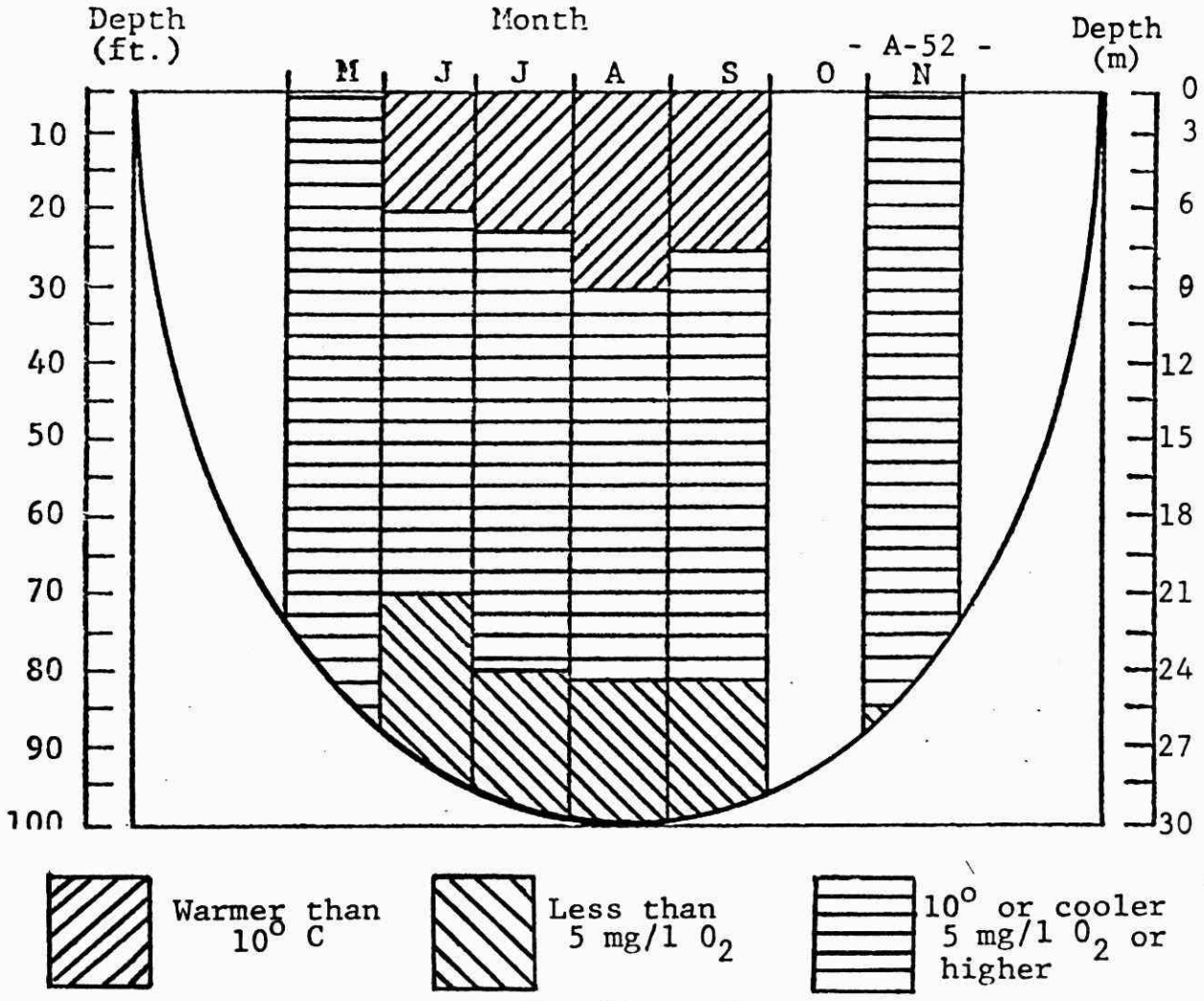
Shoreline Development

cottages, homes	37
vacant lots	53
tourist camps	0
tent, trailer sites	0
% shoreline crown	0
% shoreline patent	100

Estimated Phosphorus Supply (Annual)

Upstream lakes	38.2 kg	(84 lbs)	13%
Land runoff	139.3 kg	(306.5 lbs)	47%
Atmosphere	90.2 kg	(198.5 lbs)	30%
Shoreline Development	30.3 kg	(66 lbs)	10%
Sensitivity Index	39		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
7.6	24.9	0.7	5	95	128	9	246	0.04	7.2-8.5



Lavallee Lake

The 1976 survey of Lavallee Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Lavallee Lake (illustrated above) indicate excellent lake trout habitat. Approximately 15.2 metres (50 feet) of the lake's water column contains suitable oxygen conditions for lake trout throughout the season.

Lavallee Lake supports an existing cottage density of one unit for each 4.5 hectares (11.1 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 4.0 hectares (10 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Because of the lake's large depth and volume of bottom water, its oxygen resource is considered to have a low sensitivity to depletion.

It is concluded that additional shoreline development on Lavallee Lake could result in a decline in water clarity but would not have a serious affect on the lake's oxygen resource.

Lavallee Lake

Location: Hastings County
Faraday Township

Watershed: Trent River

Morphometry Hydrology

Surface Area	85.0 hectares (210 acres)
Mean Depth	13.3 metres (43.6 feet)
Max. Depth	31.1 metres (102 feet)
Volume	11.3 x $10^6 m^3$ (9,169 acre-feet)
Watershed Area	24.1 km^2 (9.3 square miles)
Flushing Rate	0.75 times per year

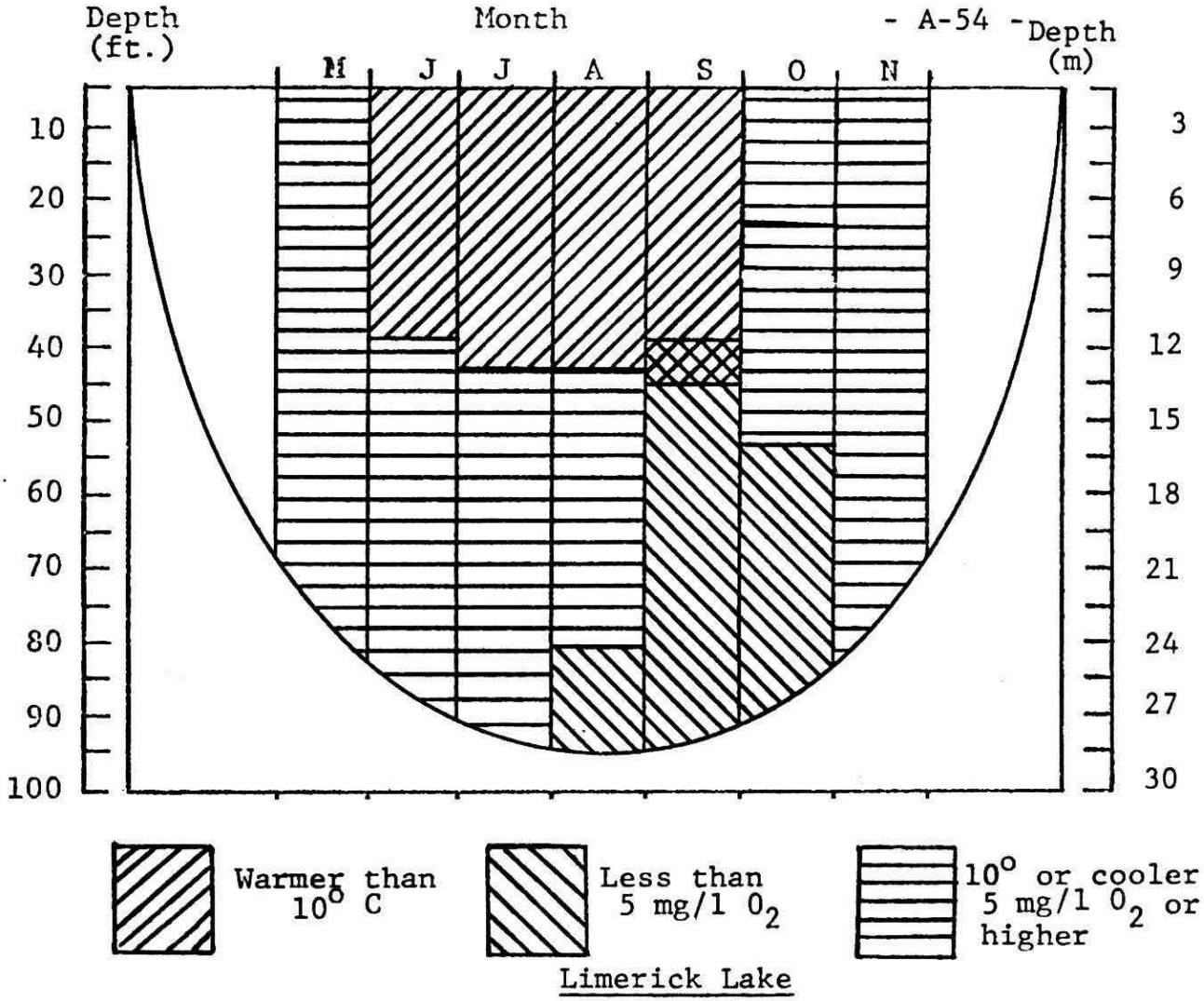
Shoreline Development

cottages, homes	19
vacant lots	2
tourist camps	1
tent, trailer sites	302
% shoreline crown	20
% shoreline patent	80

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	228.2 kg	(502 lbs)	75%
Atmosphere	64.1 kg	(141 lbs)	21%
Shoreline Development	11.8 kg	(26 lbs)	4%
Sensitivity Index	96		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.6	18.4	1.1	7	112	143	9	381	0.05	7.5-8.0



Limerick Lake

The 1977 survey of Limerick Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibiltiy measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Limerick Lake (illustrated above) indicate poor lake trout habitat. Acceptable oxygen conditions existed until September at which time a brief period of stress for lake trout occurred.

Limerick Lake supports an existing cottage density of one unit for each 5.6 hectares (13.8 acres) of lake surface area. Development of the registered vacant lots would increase the shoreline density to one unit for each 3.8 hectares (9.5 acres) of lake surface area. A large plan of subdivision involving backshore lots has also been approved at Limerick Lake.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be low. Owing to the shallow nature of Limerick Lake, its oxygen resource is considered to be quite susceptible to depletion.

It is concluded that further shoreline development on Limerick Lake would not cause a significant increase in algal production and should therefore not result in significant further oxygen depletion.

Limerick Lake

Location: Hastings County
Limerick Township

Watershed: Trent River

Morphometry Hydrology

Surface Area	744.6 hectares (1840 acres)
Mean Depth	8.4 metres (27.6 feet)
Max. Depth	29.0 metres (95 feet)
Volume	62.9 x $10^6 m^3$ (50,970 acre-feet)
Watershed Area	181.3 km^2 (70 square miles)
Flushing Rate	1.0 times per year

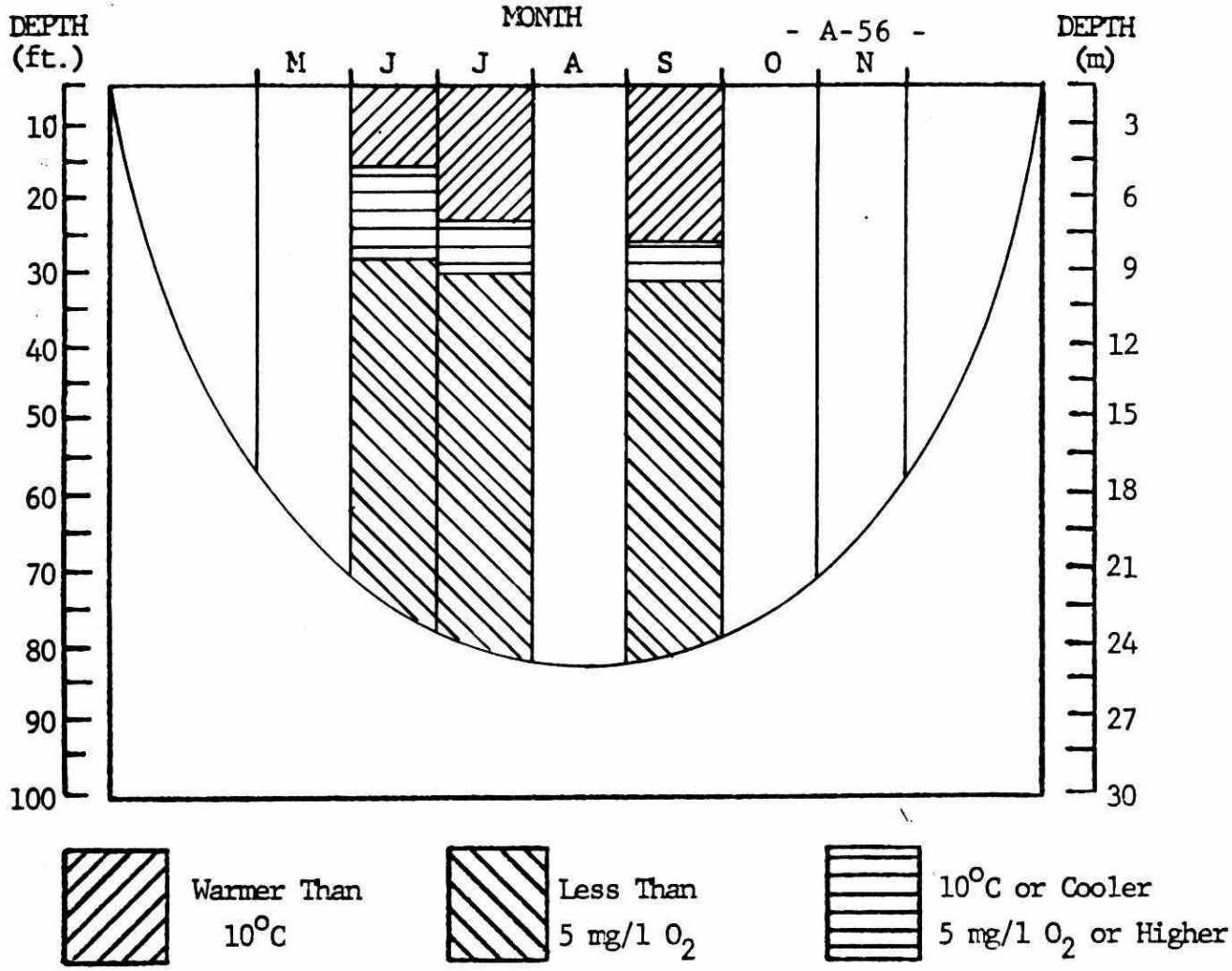
Shoreline Development

cottages, homes	133
vacant lots	61
tourist camps	1
tent, trailer sites	14
% shoreline crown	1
% shoreline patent	99

Estimated Phosphorus Supply (Annual)

Upstream lakes	390.0 kg	(858 lbs)	28%
Land runoff	531.8 kg	(1170 lbs)	38%
Atmosphere	372.7 kg	(820 lbs)	27%
Shoreline Development	98.2 kg	(216 lbs)	7%
Sensitivity Index	5		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.2	17.1	0.8	8	94	129	10	272	0.07	7.1-8.6



Limestone Lake (Brougham Township)

The 1978 survey of Limestone Lake (Brougham Township) revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles of Limestone Lake (illustrated above) indicate poor lake trout habitat. The lake did not mix at spring overturn below a depth of approximately 9.0 metres (29.5 feet) in 1978 and therefore had a highly confined zone of usable lake trout habitat throughout the year.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Because the lake does not undergo spring overturn; the remaining oxygen resource is also considered to be highly susceptible to further depletion.

It is concluded that any shoreline development would adversely affect the surface water quality (i.e. increased algal production) and also deplete the oxygen resource.

Limestone Lake (Brougham Township)

Location: Renfrew County
Brougham Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	22 hectares (54 acres)
Mean Depth	11.1 metres (36.3 feet)
Max. Depth	25 metres (81 feet)
Volume	2.42 x $10^6 m^3$ (1960 ac. ft.)
Watershed Area	2.1 km^2 (0.81 square miles)
Flushing Rate	0.3 times per year

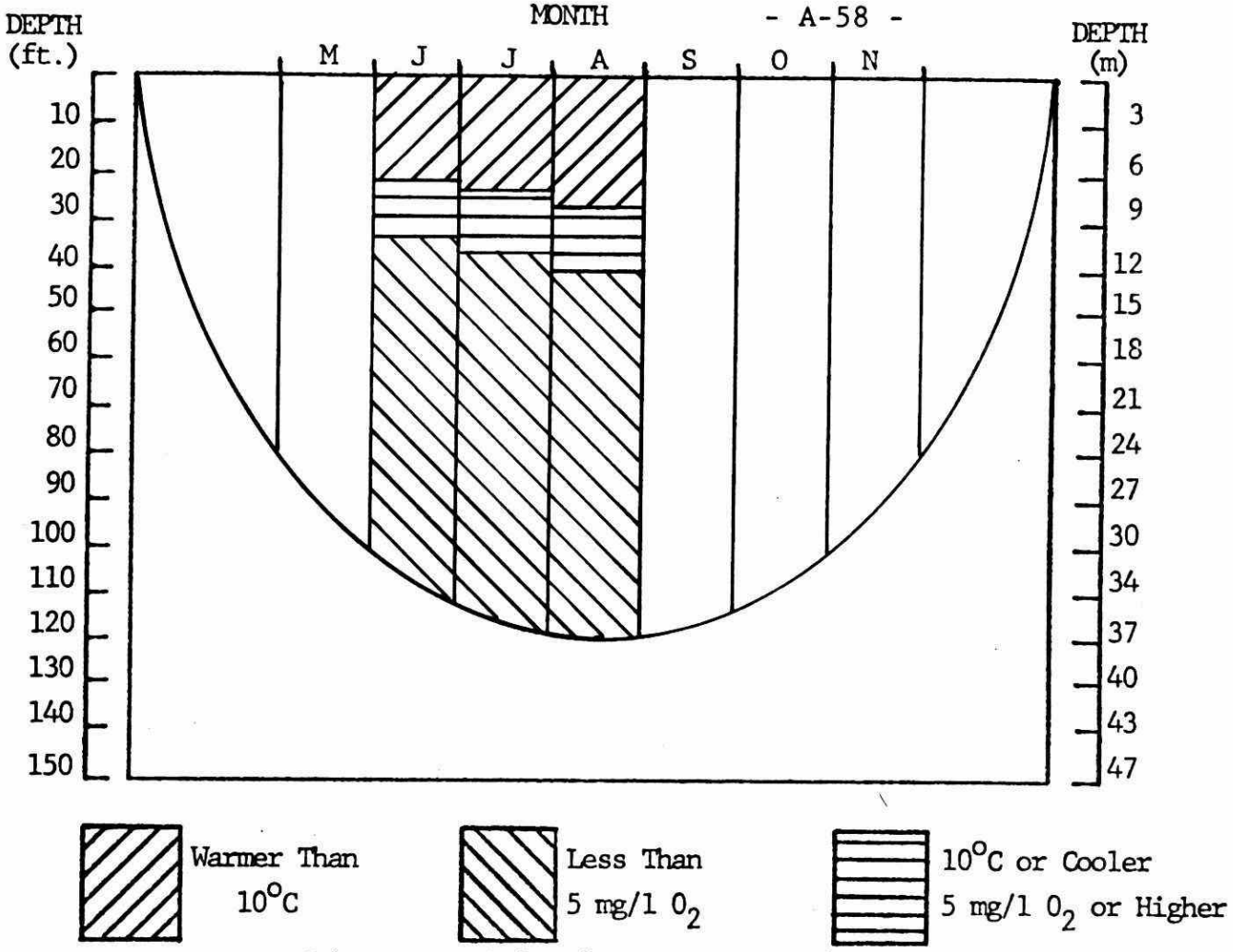
Shoreline Development

cottages, homes	0
vacant lots	0
tourist camps	0
tent, trailer sites	0
% shoreline crown	100
% shoreline patent	0

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	11.3 kg	(24.9 lbs)	41%
Atmosphere	16.5 kg	(36.3 lbs)	59%
Shoreline Development	Nil		
Sensitivity Index	1088		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
7.2	23.8	1.8	8	145	184	9	372	.07	8.0-8.3



Limestone Lake (Mayo Township)

The 1978 survey of Limestone Lake (Mayo Township) revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Limestone Lake (illustrated above) indicate marginally suitable lake trout habitat. The lake did not mix at spring overturn below a depth of approximately 11.0 metres (36.1 feet) in 1978 and therefore had a very restricted zone of suitable trout habitat throughout the year.

Limestone Lake supports an existing cottage density of one unit per 7.5 hectares (18.5 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 3.8 hectares (9.3 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Because of limited mixing, reoxygenation is low during spring overturn; the lake's oxygen resource is considered to be highly susceptible to depletion.

It is concluded that further shoreline development on Limestone Lake could cause a significant increase in algal production and a further depletion of the oxygen resource.

Limestone Lake (Mayo Township)

Location: Hastings County
Mayo Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	45 hectares (112 acres)
Mean Depth	12.6 metres (41.2 feet)
Max. Depth	36 metres (120 feet)
Volume	5.7 x $10^6 m^3$ (4369 acre-feet)
Watershed Area	3.1 km^2 (8.0 square miles)
Flushing Rate	0.2 times per year

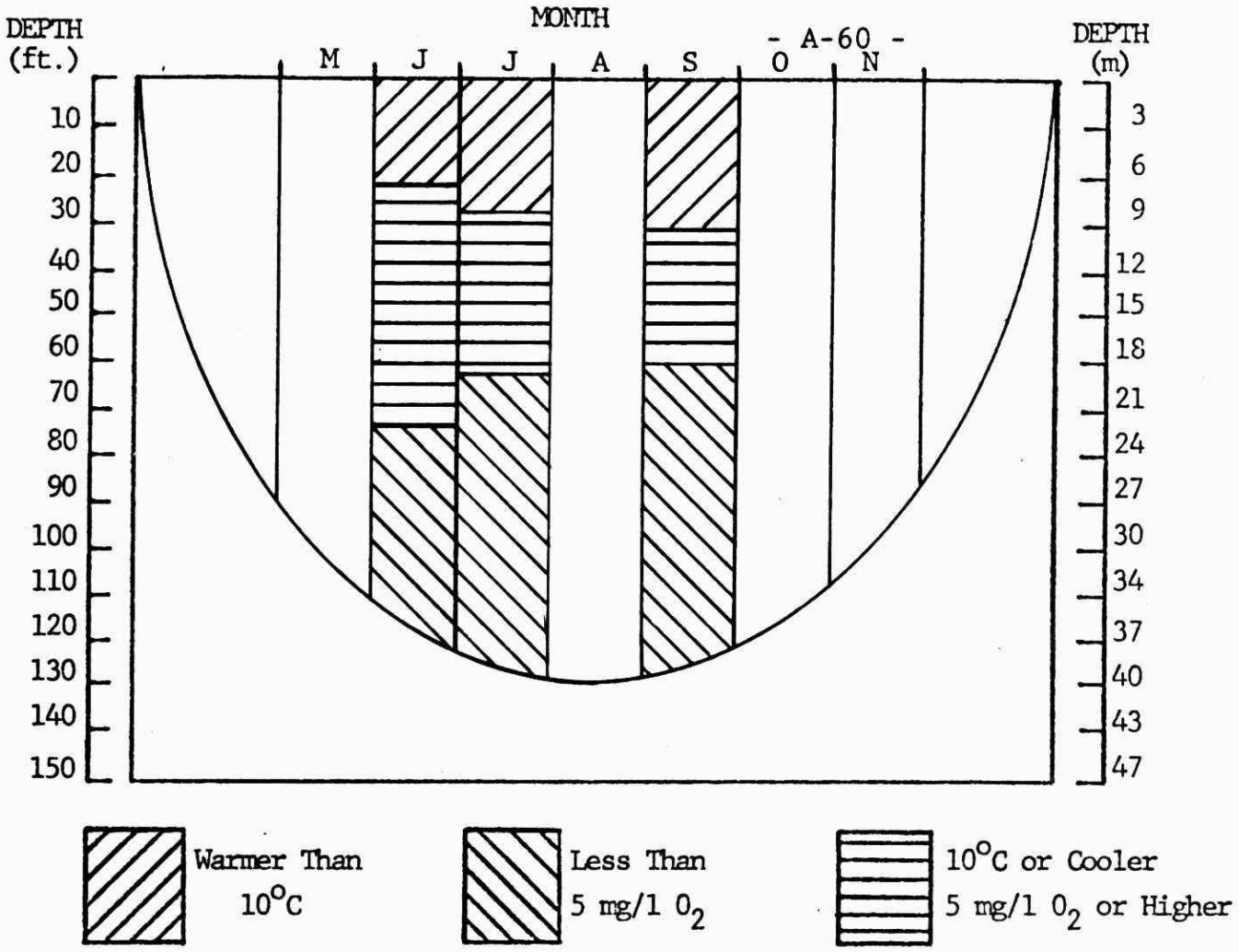
Shoreline Development

cottages, homes	6
vacant lots	6
tourist camps	0
tent, trailer sites	0
% shoreline crown	60
% shoreline patent	40

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	14.6 kg	(32.1 lbs)	28%
Atmosphere	33.8 kg	(74.4 lbs)	65%
Shoreline Development	3.7 kg	(8.1 lbs)	7%
Sensitivity Index	419		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.1	16.7	1.0	6	116	135	11	350	0.07	8.1-8.2



Little Clear

The 1978 survey of Little Clear Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles for Little Clear Lake (illustrated above) indicate good lake trout habitat remaining in September.

Little Clear Lake supports an existing cottage density of one unit per 55 hectares (136 acres). Since Little Clear Lake lies within the boundary of Frontenac Park no further cottage development is anticipated.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Because of the Lake's deep mean depth and good oxygen concentrations, the susceptibility of the oxygen resource to depletion is considered to be moderate.

It is concluded that shoreline development could adversely affect the surface water quality of Little Clear Lake, however the oxygen resource may only be slightly affected.

Little Clear

Location: Frontenac County
Bedford Township

Watershed: Cataraqui River

Morphometry Hydrology

Surface Area	55 hectares (136 acres)
Mean Depth	17.5 metres (57.5 feet)
Max. Depth	40 metres (130 feet)
Volume	9.6 x $10^6 m^3$ (7820 acre-feet)
Watershed Area	2.12 km^2 (0.82 square miles)
Flushing Rate	0.08 times per year

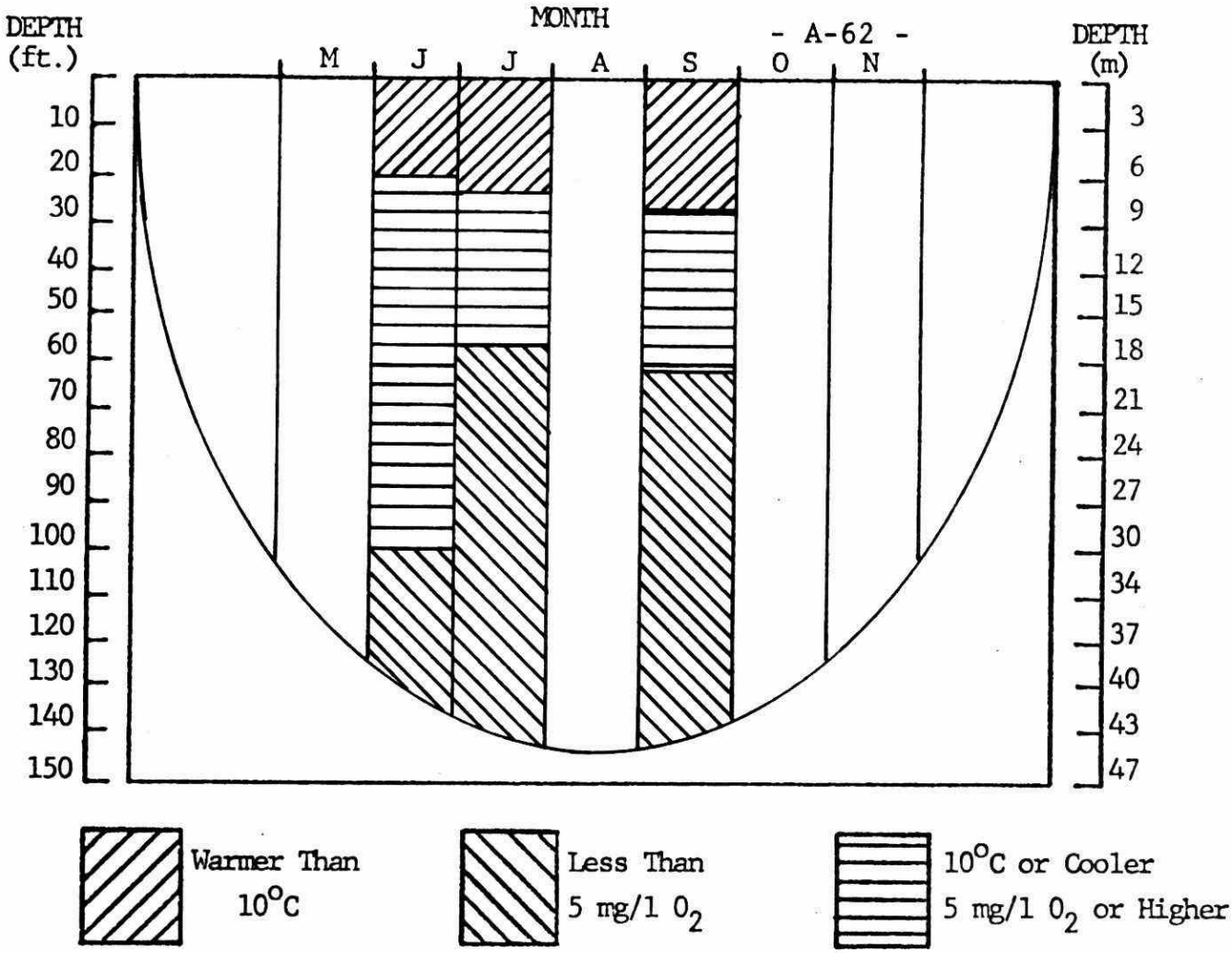
Shoreline Development

cottages, homes	1
vacant lots	0
tourist camps	0
tent, trailer sites	0
% shoreline crown	90
% shoreline patent	10

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	15.48 kg	(34.0 lbs)	27%
Atmosphere	41.28 kg	(90.8 lbs)	72%
Shoreline Development	0.61 kg	(1.3 lbs)	1%
Sensitivity Index	343		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.0	19.7	1.3	4	36	64	6	245	.08	7.4-8.0



Little Salmon Lake

The 1978 survey of Little Salmon Lake revealed excellent water quality for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (ie. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profile for Little Salmon Lake (illustrated above) indicate good lake trout habitat to September.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered high. Because of the lake's deep mean depth its oxygen resource is considered moderately susceptible to depletion.

It is concluded that shoreline development on Little Salmon Lake could affect both water clarity and the lake's dissolved oxygen regime.

Little Salmon Lake

Location: Frontenac County
Bedford Township

Watershed: Cataraqui River

Morphometry Hydrology

Surface Area	38 hectares (94 acres)
Mean Depth	16.7 metres (54.7 feet)
Max. Depth	44 metres (144 feet)
Volume	6.3 x $10^6 m^3$ (5,137 acre-feet)
Watershed Area	4.49 km^2 (11.62 square miles)
Flushing Rate	0.26 times per year

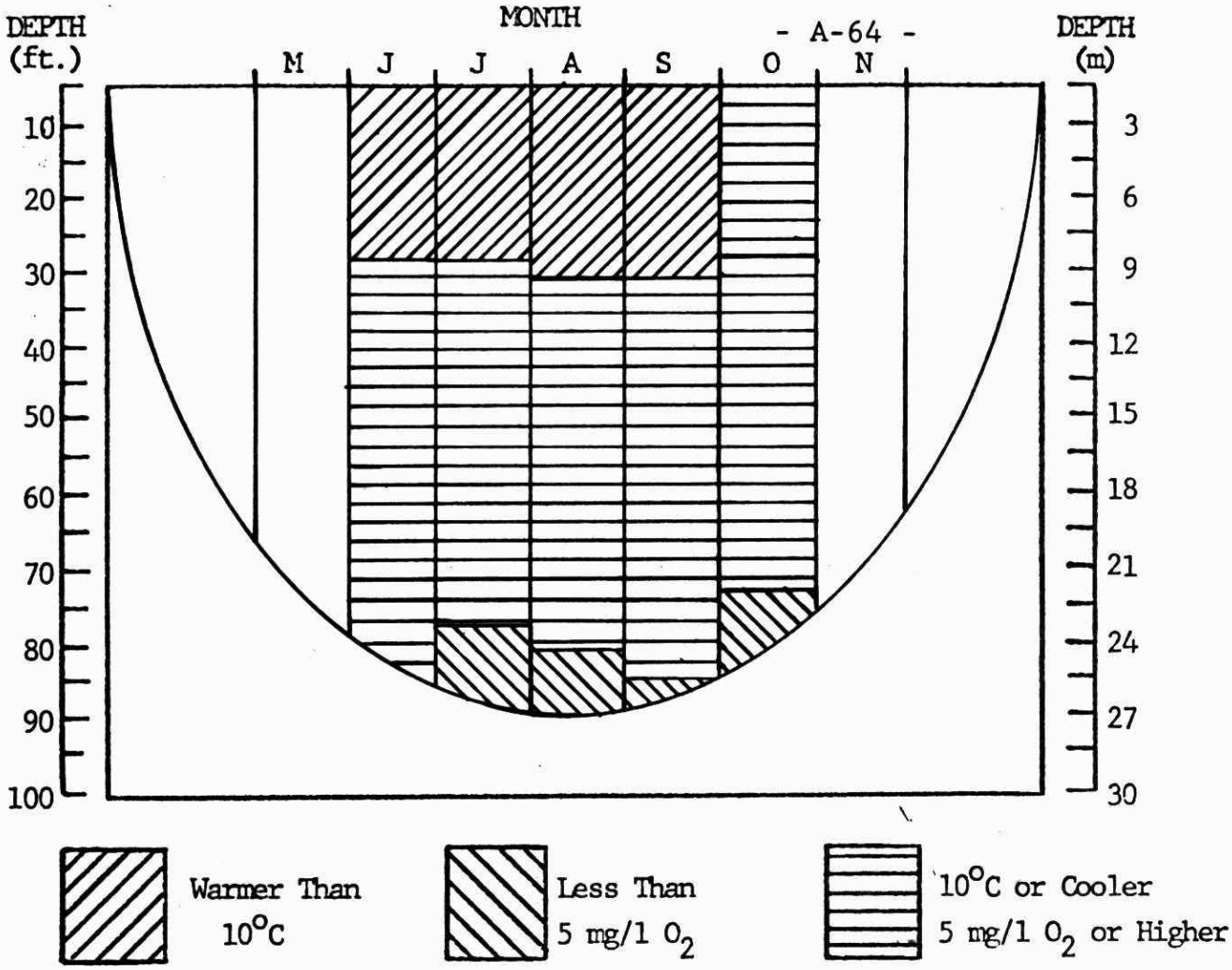
Shoreline Development

cottages, homes	0
vacant lots	0
tourist camps	0
tent, trailer sites	0
% shoreline crown	100
% shoreline patent	0

Estimated Phosphorus Supply (Annual)

Upstream lakes	22.0 kg	(48.4 lbs)	30%
Land runoff	22.6 kg	(49.6 lbs)	31%
Atmosphere	28.5 kg	(62.7 lbs)	39%
Shoreline Development	Nil		
Sensitivity Index	446		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.4	21.0	2.2	9	26	63	11	303	0.08	7.5-7.6


DEPTH (ft.)
MONTH
M J J A S O N
DEPTH (m)
10 20 30 40 50 60 70 80 90 100
3 6 9 12 15 18 21 24 27 30
Warmer Than 10°C
Less Than 5 mg/l O_2
10°C or Cooler
5 mg/l O_2 or Higher

Lower Hay Lake

The 1978 survey of Lower Hay Lake revealed good water quality for recreational usage. Seasonal average chlorophyll and Secchi disc measurements indicated a moderate level of biological productivity (i.e. algae) and a corresponding moderate degree of water clarity.

The temperature and oxygen profiles of Lower Hay Lake (illustrated above) indicate excellent lake trout habitat throughout the season.

Lower Hay Lake supports an existing cottage density of one unit per 26.4 hectares (65 acres) of lake surface area.

Based on the information provided in Table 1, the potential of further development affecting the surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be low. Similarly because of the lake's excellent oxygen resource its susceptibility to oxygen depletion is considered to be low.

It is concluded that further shoreline development on Lower Hay Lake would have little effect on water quality conditions.

Lower Hay Lake

Location: District of Nipissing
Sabine Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	449 hectares (1109 acres)
Mean Depth	9.3 metres (30.5 feet)
Max. Depth	28.7 metres (94.1 feet)
Volume	41.7 x $10^6 m^3$ (33,851 acre-feet)
Watershed Area	153 km^2 (59.1 square miles)
Flushing Rate	1.3 times per year

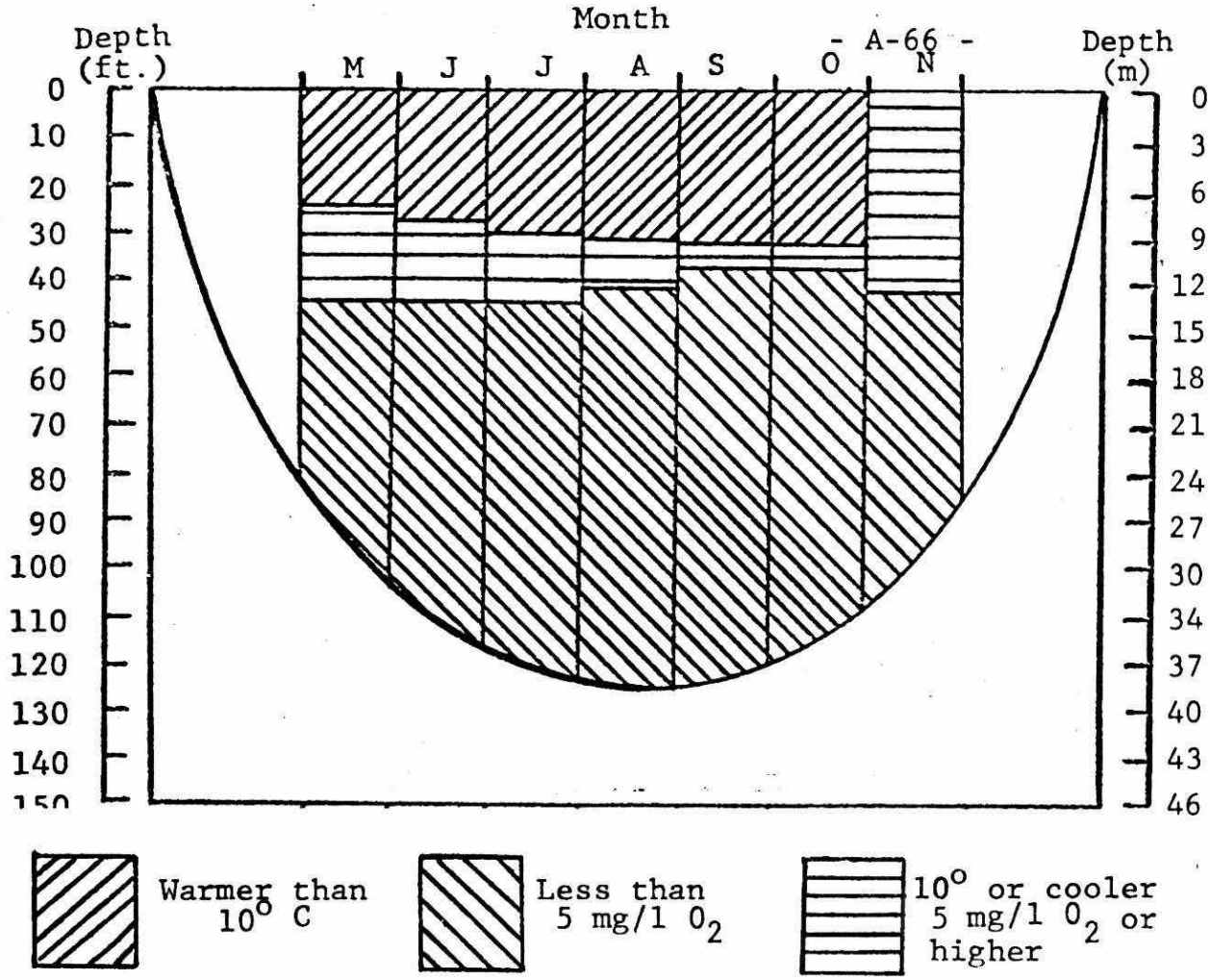
Shoreline Development

cottages, homes	17
vacant lots	information not available
tourist camps	0
tent, trailer sites	0
% shoreline crown	80
% shoreline patent	20

Estimated Phosphorus Supply (Annual)

Upstream lakes	626.5 kg	(1378.3 lbs)	44%
Land runoff	445.0 kg	(202.3 lbs)	31%
Atmosphere	336.8 kg	(153.1 lbs)	24%
Shoreline Development	10.5 kg	(4.8 lbs)	1%
Sensitivity Index	8		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
3.6	11.8	2.4	17	6	25	10	337	0.17	6.3-6.5



Mayo (Crooked) Lake

The 1977 survey of Mayo (Crooked) Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Mayo Lake (illustrated above) indicate marginally suitable lake trout habitat. The lake did not mix at spring overturn below a depth of approximately 12.2 metres (40 feet) in 1977 and therefore had a highly confined zone of usable lake trout habitat throughout the year. The lake actually consists of three basins. Water quality conditions in all three basins were almost identical so the lake is being discussed as a single body of water.

Mayo Lake supports an existing cottage density of one unit for each 3.6 hectares (8.9 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 3.1 hectares (7.7 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. Because of the limited mixing and re-oxygenation during spring overturn the lake's oxygen resource is considered to be highly susceptible to further depletion.

It is concluded that further shoreline development on Mayo Lake could cause a significant increase in algal production and further depletion of the oxygen resource.

Mayo (Crooked) Lake

Location: Hastings County
Mayo Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	182.9 hectares (452 acres)
Mean Depth	7.6 metres (24.9 feet)
Max. Depth	38.1 metres (125 feet)
Volume	13.9 x $10^6 m^3$ (11,270 acre-feet)
Watershed Area	18.9 km^2 (7.3 square miles)
Flushing Rate	0.4 times per year

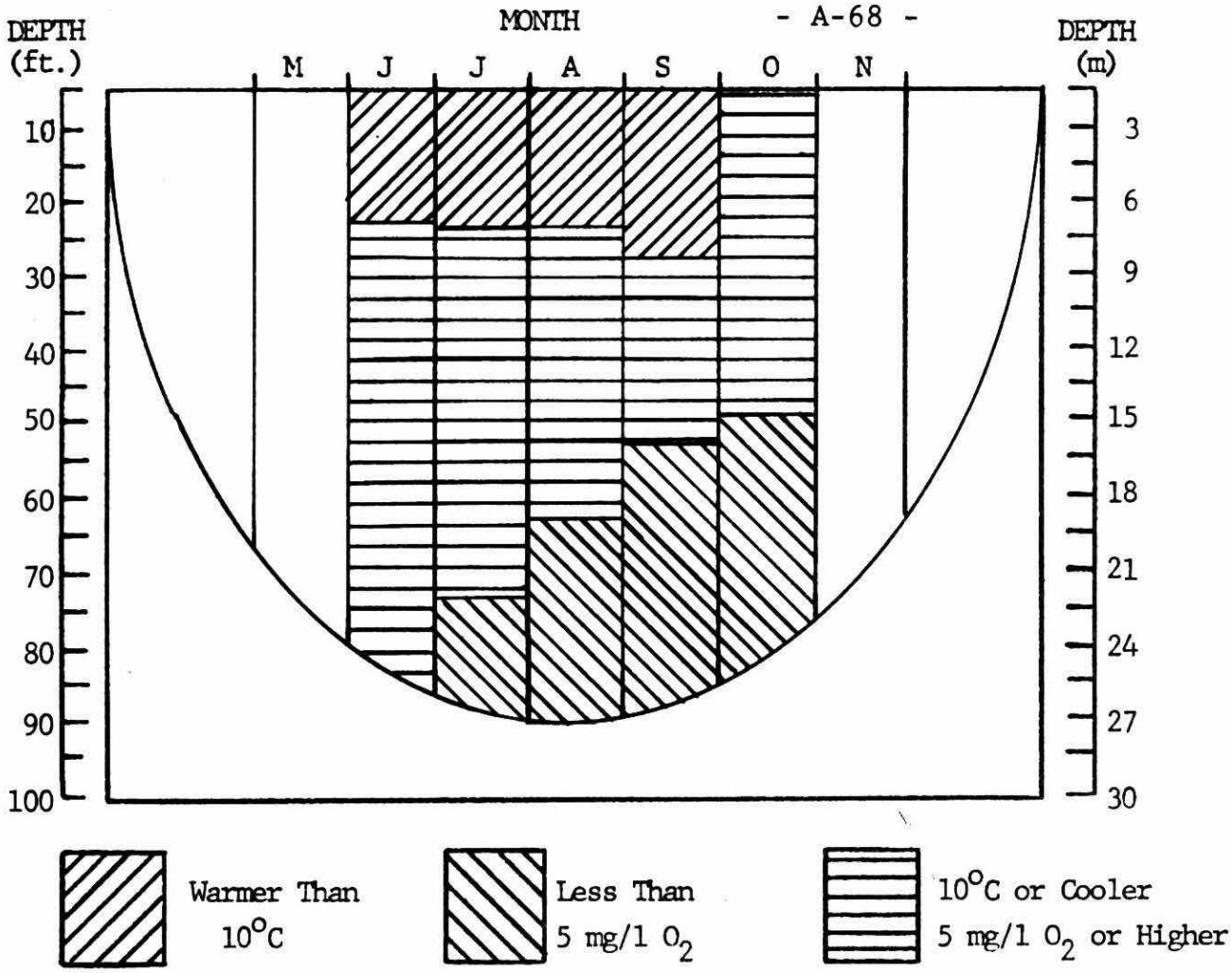
Shoreline Development

cottages, homes	51
vacant lots	8
tourist camps	0
tent, trailer sites	0
% shoreline crown	83
% shoreline patent	17

Estimated Phosphorus Supply (Annual)

Upstream lakes	7 kg (15 lbs)	3%
Land runoff	73 kg (161 lbs)	36%
Atmosphere	92 kg (203 lbs)	45%
Shoreline Development	34 kg (75 lbs)	16%
Sensitivity Index	51	

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.9	22.6	0.8	5	107	139	10	291	0.04	7.7-8.5


DEPTH (ft.)
MONTH
M J J A S O N
DEPTH (m)
10 20 30 40 50 60 70 80 90 100
3 6 9 12 15 18 21 24 27 30
Warmer Than 10°C
Less Than 5 mg/1 O2
10°C or Cooler
5 mg/1 O2 or Higher

McCauley Lake

The 1978 survey of McCauley Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) however only a moderate degree of water clarity was recorded.

The temperature and oxygen profiles of McCauley Lake (illustrated above) indicate good lake trout habitat.

McCauley Lake supports an existing cottage density of one unit per 3.1 hectares (7.7 acres).

Based on the information provided in Table 1, the potential of further shoreline development affecting surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. Similarly because of the lake's small deep water volume its oxygen resource is considered moderately susceptible to depletion.

It is concluded that further shoreline development could have a significant effect on both surface water quality and the deep water oxygen resource.

McCauley Lake

Location: Nipissing District
Airy and Murchinison Townships

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	121 hectares (300 acres)
Mean Depth	6.6 metres (21.6 feet)
Max. Depth	28 metres (91 feet)
Volume	8.0 x $10^6 m^3$ (6,485 acre-feet)
Watershed Area	66.4 km^2 (25.6 square miles)
Flushing Rate	2.9 times per year

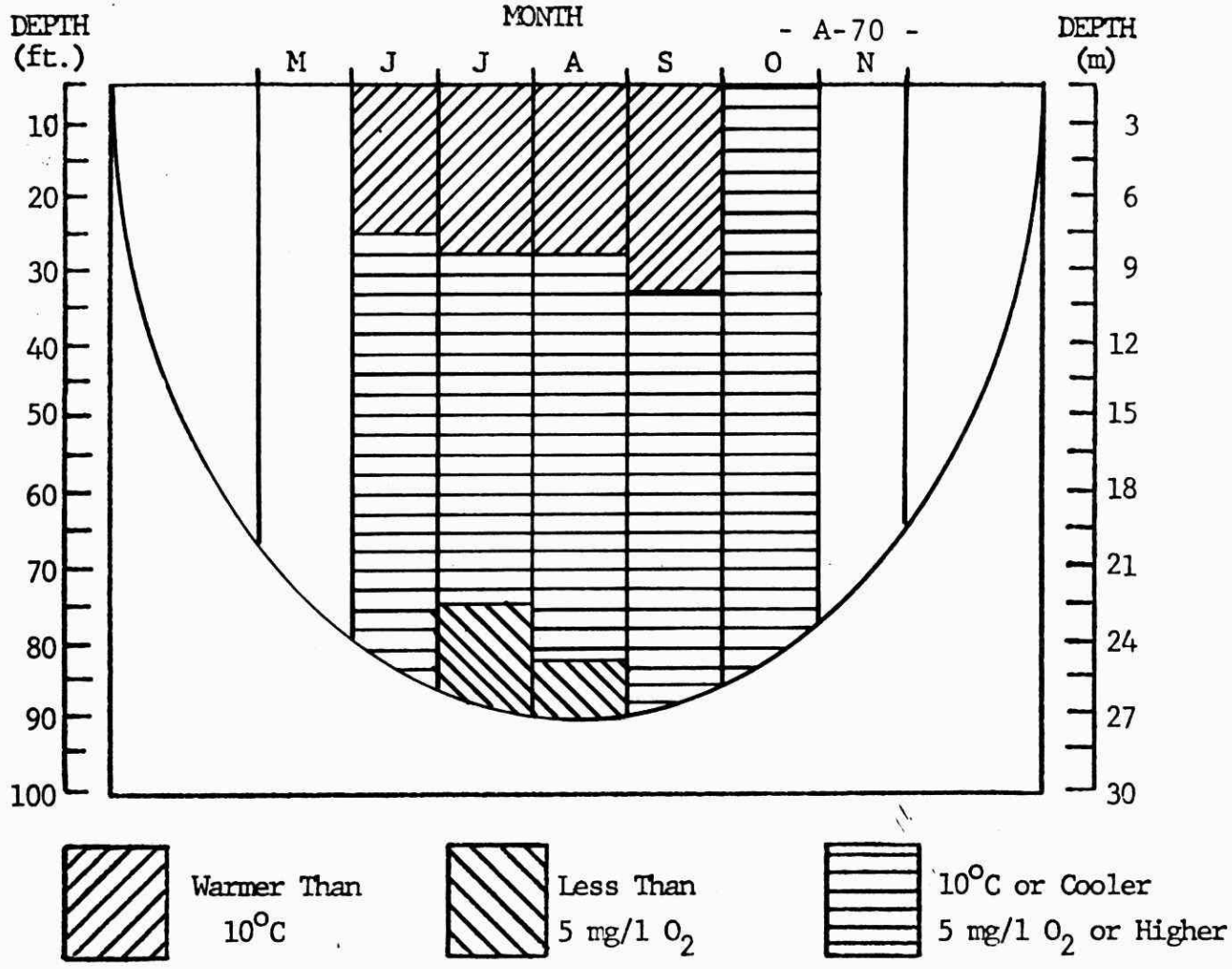
Shoreline Development

cottages, homes	39
vacant lots	information not available
tourist camps	1
tent, trailer sites	0
% shoreline crown	20
% shoreline patent	80

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil	
Land runoff	267 kg (587.4 lbs)	70%
Atmosphere	90.8 kg (199.8 lbs)	24%
Shoreline Development	24 kg (52.8 lbs)	6%
Sensitivity Index	36	

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
3.5	11.4	2.0	20	7	25	11	338	0.13	6.4-6.7



McKenzie Lake

The 1978 survey of McKenzie Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles for McKenzie Lake (illustrated above) indicate excellent lake trout habitat.

McKenzie Lake supports an existing cottage density of one unit per 5.9 hectares (14.6 acres).

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. From the ample oxygen contained in the deep water volume the oxygen susceptibility to further depletion is considered low.

It is concluded that further shoreline development on McKenzie Lake may have an effect on surface water quality but little effect on the deep water oxygen resource.

McKenzie Lake

Location: Nipissing District
Sabine Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	312 hectares (770 acres)
Mean Depth	9.0 metres (29.5 feet)
Max. Depth	34 metres (110 feet)
Volume	28.1 x $10^6 m^3$ (22,780 acre-feet)
Watershed Area	68.9 km^2 (26.6 square miles)
Flushing Rate	0.8 times per year

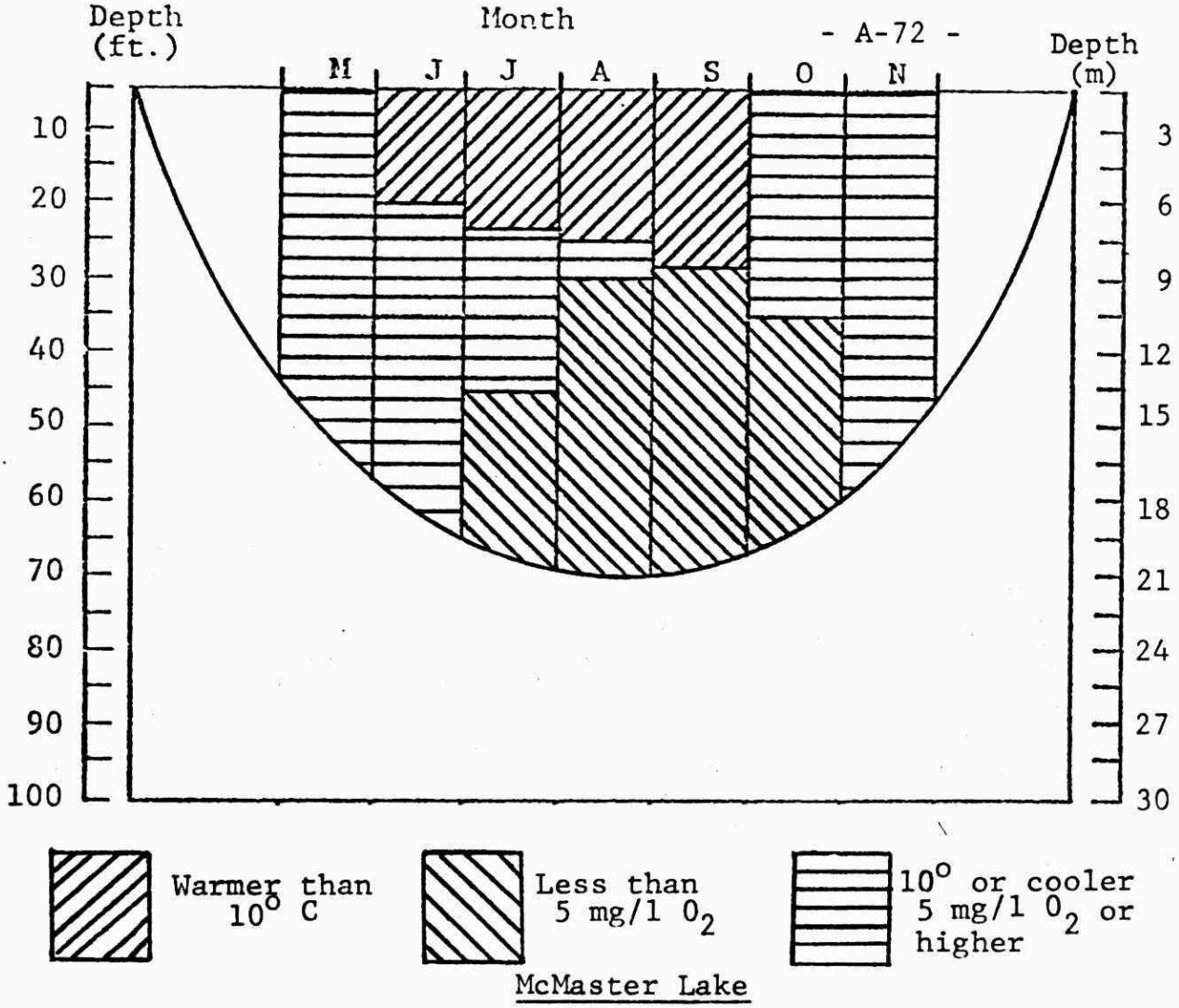
Shoreline Development

cottages, homes	53
vacant lots	information not available
tourist camps	1
tent, trailer sites	0
% shoreline crown	50
% shoreline patent	50

Estimated Phosphorus Supply (Annual)

Upstream lakes	49.0 kg (107.8 lbs)	8%
Land runoff	281.0 kg (618.2 lbs)	47%
Atmosphere	234.0 kg (514.8 lbs)	39%
Shoreline Development	39.4 kg (86.7 lbs)	7%
Sensitivity Index	17	

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
4.5	14.8	2.0	20	6	30	6	347	0.07	4.7-6.6



McMaster Lake

The 1977 survey of McMaster Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of McMaster Lake (illustrated above) indicate poor lake trout habitat. Gradual depletion of the lake's oxygen resource is evident and a condition of stress exists by September.

The shoreline of McMaster Lake supports an existing cottage density of one unit for each 7.8 hectares (19.4 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 5.4 hectares (13.3 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Similarly, owing to the lake's shallow nature, and relatively small volume of bottom water, its oxygen resource is considered to be highly susceptible to further depletion.

It is concluded that further shoreline development on McMaster Lake could cause a significant increase in algal production and depletion of the lake's oxygen resource.

McMaster Lake

Location: Renfrew County
Sherwood, Jones and Burns Townships

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	102.0 hectares (252 acres)
Mean Depth	7.8 metres (25.6 feet)
Max. Depth	21.0 metres (69 feet)
Volume	8.0 x $10^6 m^3$ (6,490 acre-feet)
Watershed Area	7.0 km^2 (2.7 square miles)
Flushing Rate	0.3 times per year

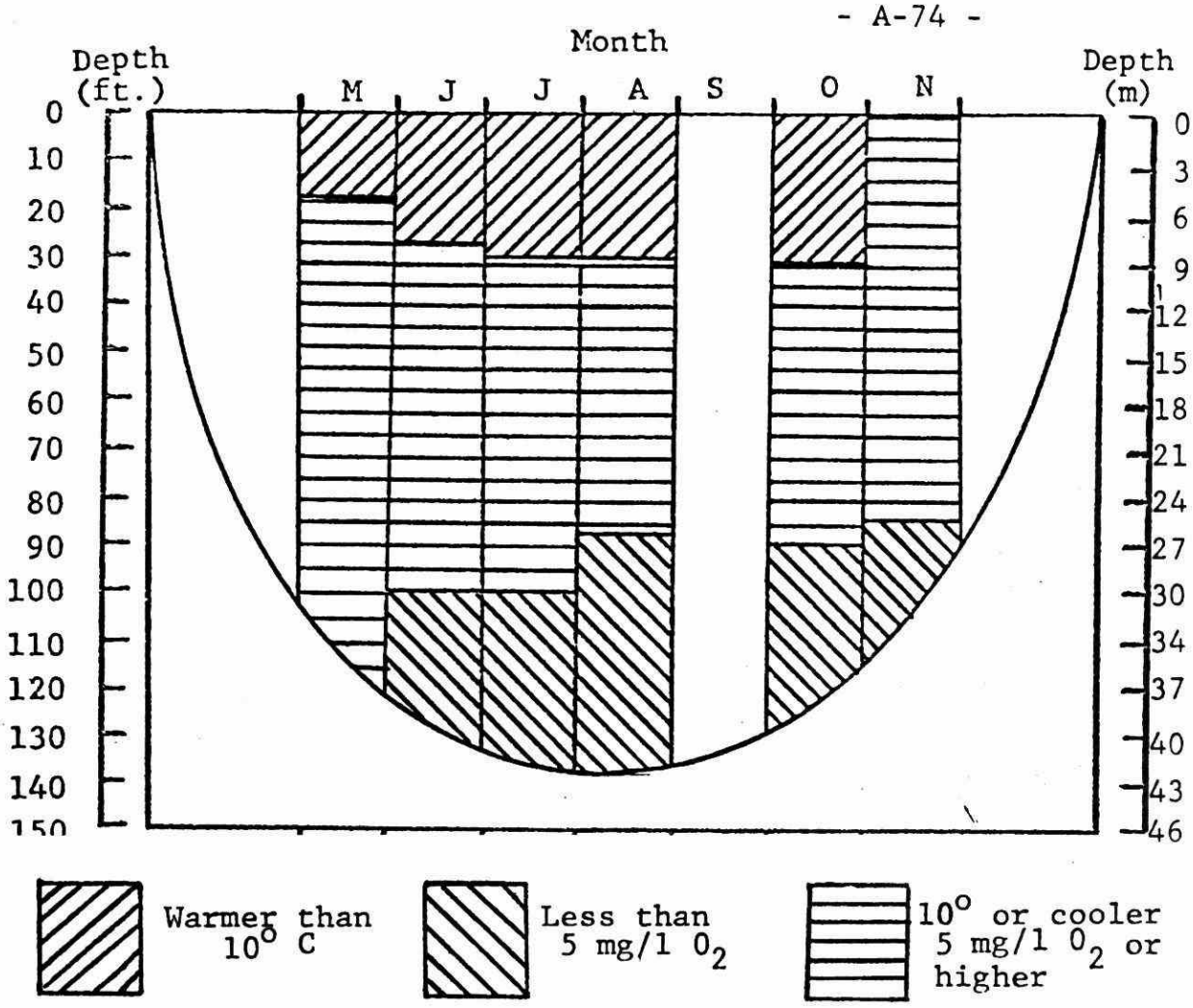
Shoreline Development

cottages, homes	13
vacant lots	6
tourist camps	0
tent, trailer sites	0
% shoreline crown	25
% shoreline patent	75

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	59.1 kg	(130 lbs)	50%
Atmosphere	50.9 kg	(112 lbs)	43%
Shoreline Development	8.2 kg	(18 lbs)	7%
Sensitivity Index	134		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.1	16.7	1.1	12	21	46	10	260	0.13	7.0-7.8



Mephisto (Devil) Lake

The 1977 survey of Mephisto (Devil) Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Mephisto Lake (illustrated above) indicate good to excellent lake trout habitat. Approximately 18.3 metres (60 feet) of the water column contained suitable oxygen conditions for lake trout.

Mephisto Lake supports an existing cottage density of one unit for each 3.9 hectares (9.6 acres) of lake surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate.

It is concluded that the effect of further shoreline development on Mephisto Lake would be limited to a potential slight decline in water clarity which would not significantly alter the recreational use potential of the lake.

Mephisto (Devil) Lake

Location: Hastings County
Tudor and Cashel Townships

Watershed: Trent River

Morphometry Hydrology

Surface Area	151.0 hectares (373 acres)
Mean Depth	16.2 metres (53.2 feet)
Max. Depth	42.1 metres (138 feet)
Volume	24.5 x $10^6 m^3$ (19,854 acre-feet)
Watershed Area	65.0 km^2 (25.1 square miles)
Flushing Rate	0.9 times per year

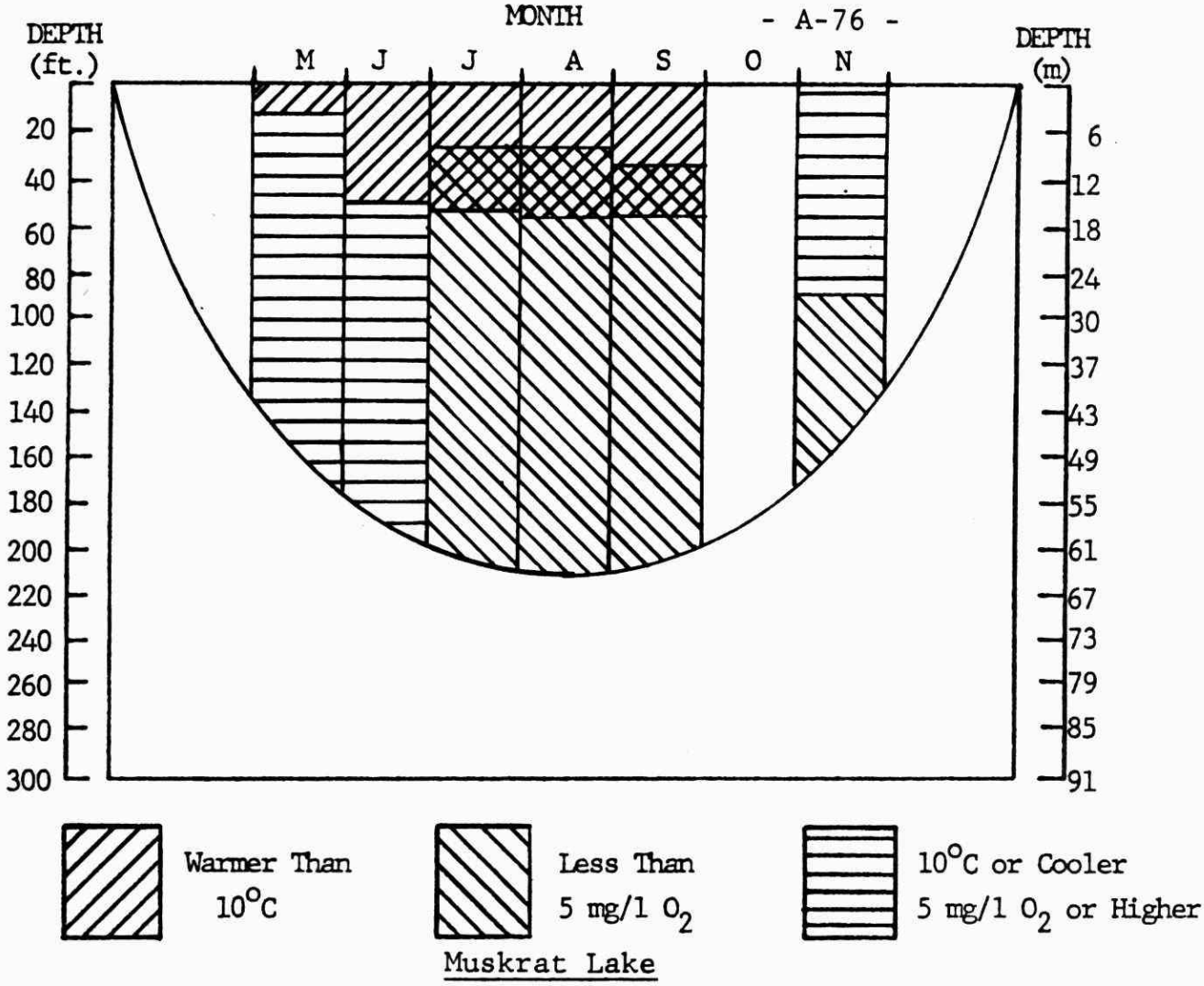
Shoreline Development

cottages, homes	39
vacant lots	0
tourist camps	0
tent, trailer sites	0
% shoreline crown	54
% shoreline patent	46

Estimated Phosphorus Supply (Annual)

Upstream lakes	45.0 kg	(99 lbs)	13%
Land runoff	201.4 kg	(443 lbs)	58%
Atmosphere	75.9 kg	(167 lbs)	22%
Shoreline Development	25.9 kg	(57 lbs)	7%
Sensitivity Index	31		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.6	21.7	0.8	5	107	135	10	297	0.12	7.7-8.5



Muskrat Lake

The 1978 survey of Muskrat Lake revealed poor water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a high level of biological productivity (i.e. algae) and a corresponding low degree of water clarity.

Temperature and oxygen profiles for Muskrat Lake (illustrated above) indicate poor lake trout habitat from early July to September.

Muskrat Lake supports an existing cottage density of one unit per 7.8 hectares (19.2 acres) of lake surface area. Development of the registered vacant lots would increase this density to 5.4 hectares (13.3 acres) per cottage.

Based on the location of Muskrat Lake in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal density and decreased water clarity) is considered to be low. The oxygen resource is poor for lake trout however further depletion is not expected to occur from any increase in shoreline development.

It is concluded that further shoreline development on Muskrat Lake would have a negligible affect on surface water quality or the oxygen resource.

Muskrat Lake

Location: Renfrew County
Westmeath and Ross Townships

Watershed: Ottawa River

Morphometry Hydrology

Surface Area	1201.6 hectares (2969.2 acres)
Mean Depth	17.7 metres (58.2 feet)
Max. Depth	64 metres (210 feet)
Volume	213.2 x $10^6 m^3$ (172,807 acre-feet)
Watershed Area	480.9 km^2 (185.6 square miles)
Flushing Rate	0.8 times per year

Shoreline Development

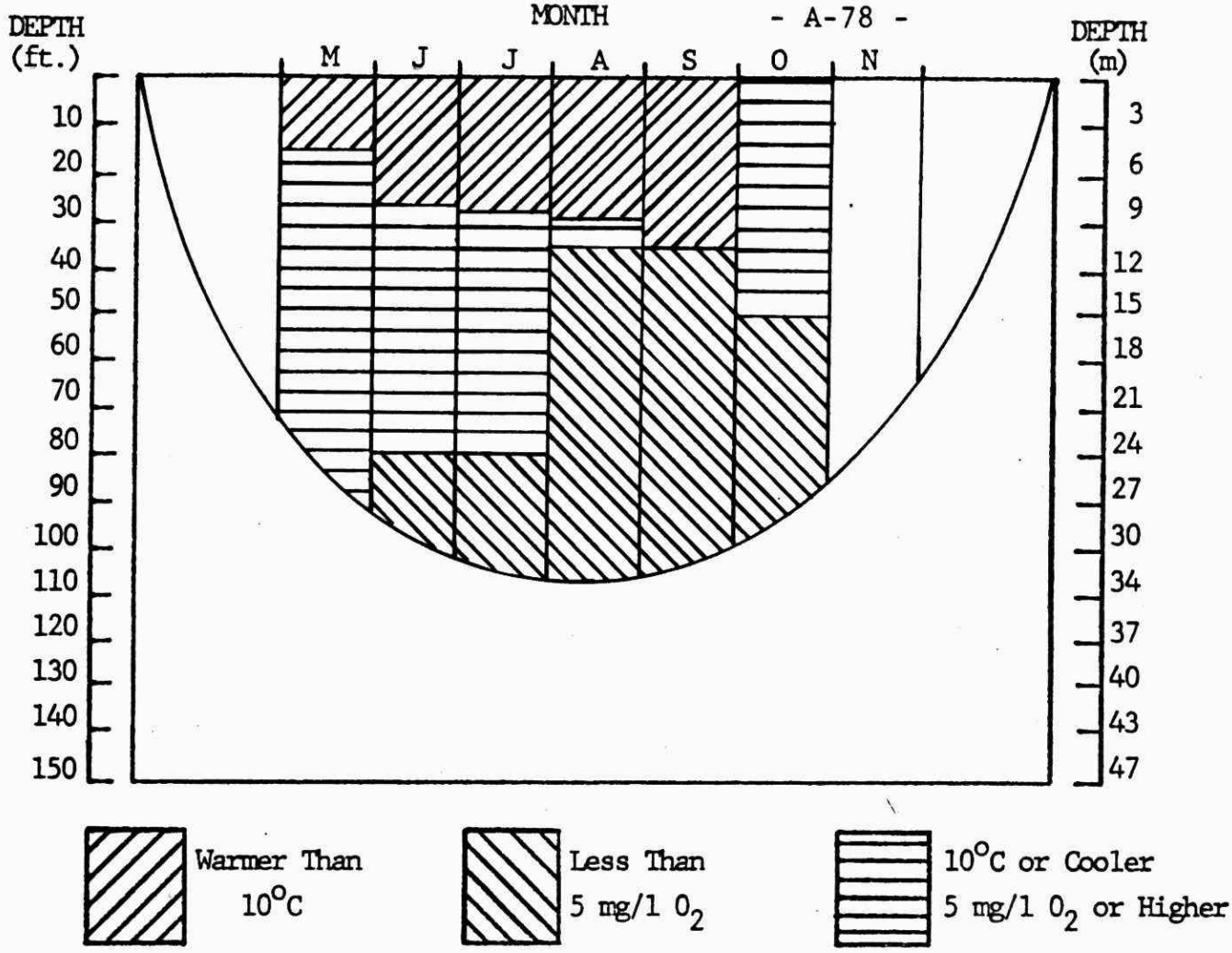
cottages, homes	134, 21
vacant lots	68
tourist camps	5
tend, trailer sites	346
% shoreline crown	0
% shoreline patent	100

Estimated Phosphorus Supply (Annual)

Upstream lakes	1041.3 kg (2290.2 lbs)	16%
Land runoff	3456.3 kg (7603.9 lbs)	53%
Atmosphere	900.0 kg (1980.0 lbs)	14%
Shoreline Development	1100.0 kg (2868.4 lbs)	17%
Sensitivity Index	2	

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
2.6	8.5	7.0	13	96	137	24	519	.08	8.1-8.4

* Includes the Town of Cobden



Norway Lake

The 1978 survey of Norway Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles (illustrated above) show poor lake trout habitat exists for late August and September.

Norway Lake supports an existing cottage density of one unit per 2.2 hectares (5.4 acres) of lake surface area. Development of the registered vacant lots would increase the cottage density to one unit per 1.9 hectares (4.6 acres) of lake surface area.

Based on the information presented in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. The oxygen resource is currently very marginal for lake trout and is considered to be highly susceptible to further depletion.

It is concluded that further shoreline development could cause both an increase in algal production and further depletion of the lake's oxygen resource.

Norway Lake

Location: Renfrew County
Bagot Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	271 hectares (670 acres)
Mean Depth	9.4 metres (30.8 feet)
Max. Depth	37 metres (120 feet)
Volume	25.5 x $10^6 m^3$ (20,636 acre-feet)
Watershed Area	14.4 km^2 (5.56 square miles)
Flushing Rate	0.2 times per year

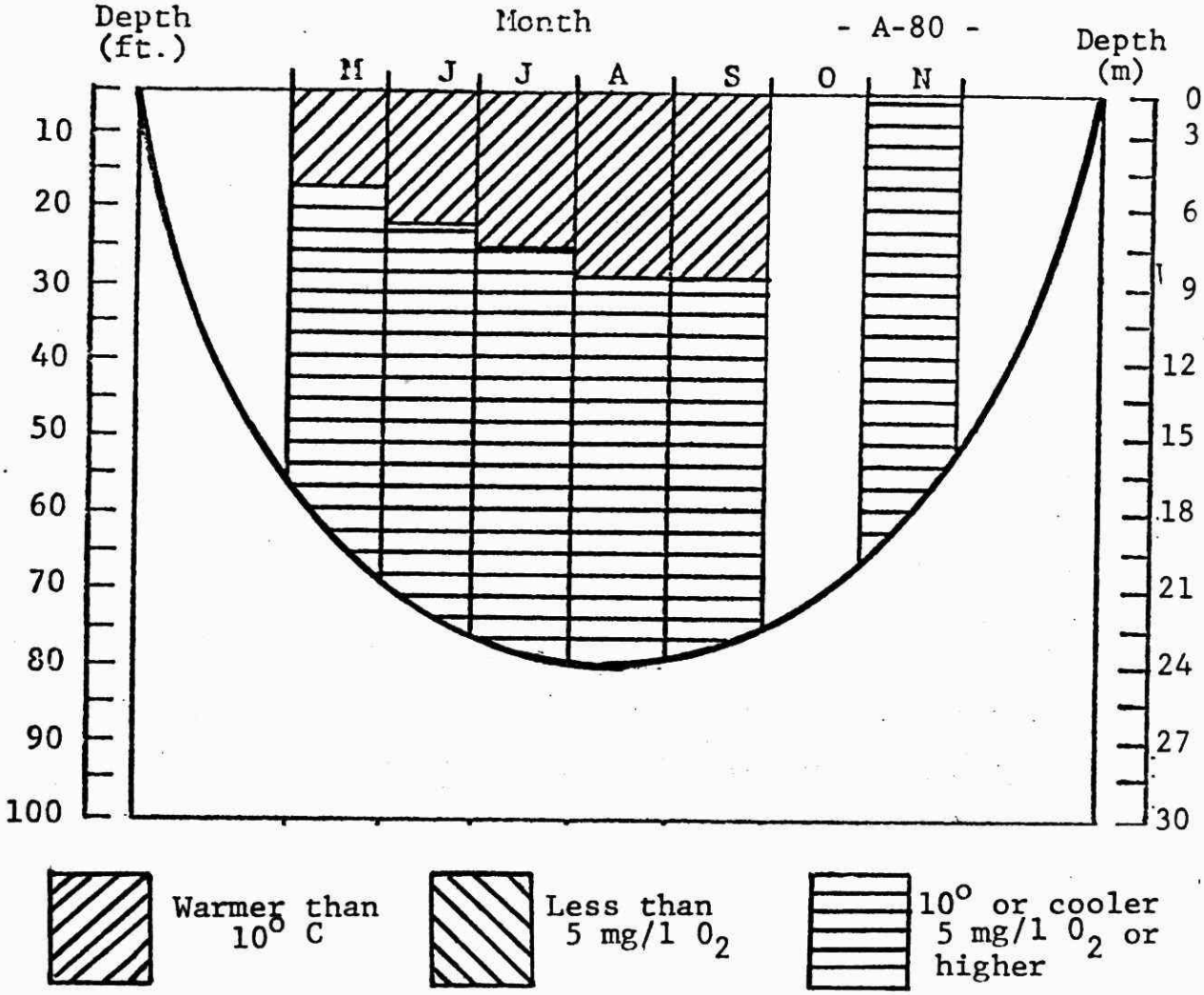
Shoreline Development

cottages, homes	124
vacant lots	20
tourist camps	0
tent, trailer sites	0
% shoreline crown	1
% shoreline patent	99

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	114.6 kg	(252.1 lbs)	23%
Atmosphere	317.8 kg	(699.2 lbs)	62%
Shoreline Development	76.4 kg	(168.1 lbs)	15%
Sensitivity Index	80		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.1	16.6	1.5	10	105	123	10	578	.08	7.9-8.3



Otter (Cotter) Lake

The 1976 survey of Otter (Cotter) Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Otter Lake (illustrated above) indicate excellent lake trout habitat. The entire lake's water column contains oxygen conditions suitable for lake trout.

Otter Lake supports an existing cottage density of one unit for each 16.3 hectares (40.4 acres) of lake surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. Because of the lake's relatively large depth and volume of bottom water and reasonably high flushing rate, its oxygen resource is considered to have a low susceptibility to depletion.

It is concluded that further shoreline development on Otter Lake would have little effect on water quality conditions.

Otter (Cotter) Lake

Location: Lennox & Addington County
Ashby Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	229.1 hectares (566 acres)
Mean Depth	8.6 metres (28.2 feet)
Max. Depth	29.3 metres (96 feet)
Volume	19.7 x $10^6 m^3$ (15,961 acre-feet)
Watershed Area	73.6 km^2 (28.4 square miles)
Flushing Rate	1.3 times per year

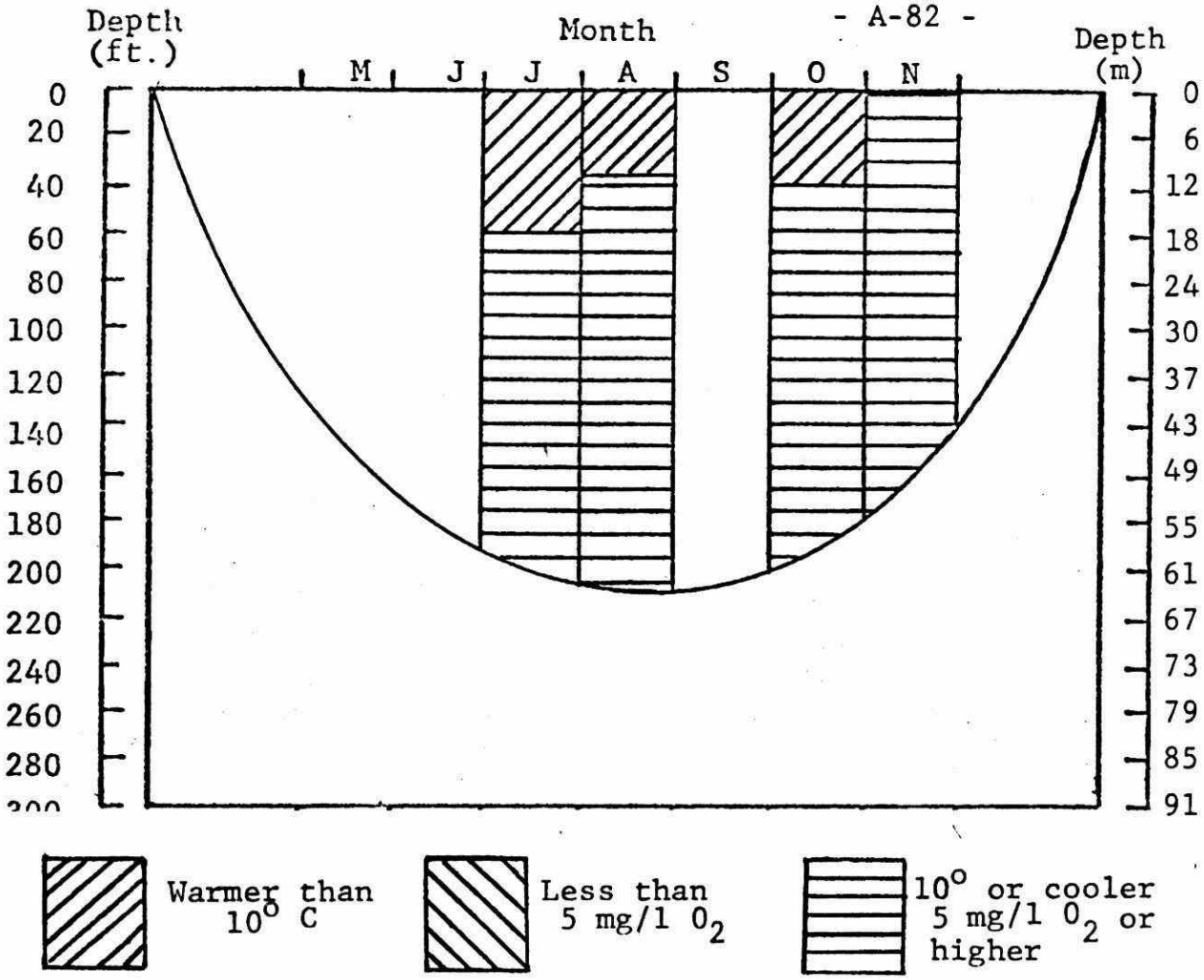
Shoreline Development

cottages, homes	14
vacant lots	0
tourist camps	0
tent, trailer sites	0
% shoreline crown	
% shoreline patent	

Estimated Phosphorus Supply (Annual)

Upstream lakes	99.1 kg	(218 lbs)	15%
Land runoff	223.6 kg	(492 lbs)	56%
Atmosphere	172.3 kg	(379 lbs)	27%
Shoreline Development	8.6 kg	(19 lbs)	2%
Sensitivity Index	21		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.2	17.0	1.5	18	15	34	20	312	0.15	6.4-6.6



Papineau Lake

The 1977 survey of Papineau Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Papineau Lake (illustrated above) indicate excellent lake trout habitat. The entire water column contains suitable oxygen conditions for lake trout.

Papineau Lake supports an existing cottage density of one unit for each 3.0 hectares (7.3 acres) of lake surface area. Development of the registered vacant lots would increase the cottage density to one unit for each 2.5 hectares (6.2 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be low. Similarly because of the lake's large depth and volume of bottom water, its oxygen resource is considered to have a low susceptibility to depletion.

It is concluded that further shoreline development on Papineau Lake would have little effect on water quality conditions.

Papineau Lake

Location: Hastings County
Wicklow and Bangor Townships

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	781.1 hectares (1930 acres)
Mean Depth	18.3 metres (60 feet)
Max. Depth	64.0 metres (210 feet)
Volume	143.0 $x_2 10^6 m^3$ (115,931 acre-feet)
Watershed Area	47.9 km^2 (18.5 square miles)
Flushing Rate	0.1 times per year

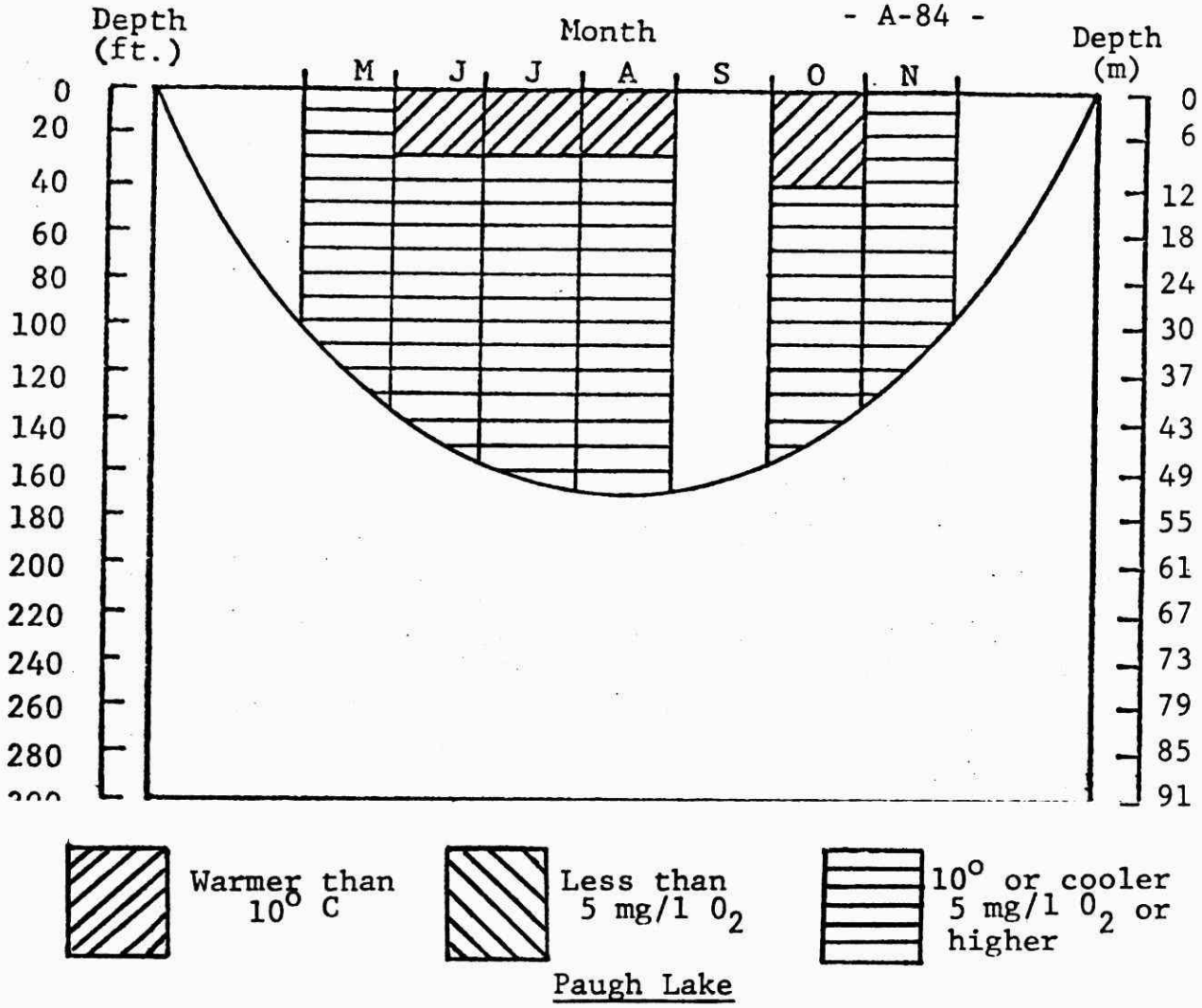
Shoreline Development

cottages, homes	266
vacant lots	47
tourist camps	4
tent, trailer sites	39
% shoreline crown	26
% shoreline patent	74

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	219 kg	(483 lbs)	27%
Atmosphere	392 kg	(865 lbs)	49%
Shoreline Development	188 kg	(415 lbs)	24%
Sensitivity Index	7		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
8.3	27.2	0.8	8	10	34	9	211	0.06	6.7-7.6



Paugh Lake

The 1977 survey of Paugh Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Paugh Lake (illustrated above) indicate excellent lake trout habitat. The lake's entire water column contains suitable oxygen conditions for lake trout.

Paugh Lake supports an existing cottage density of one unit for each 9.3 hectares (22.9 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 6.7 hectares (16.6 acres) of lake surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be low. Similarly because of the lake's large depth and volume of bottom water, its oxygen rsource is considered to have a low susceptibility to depletion.

It is concluded that further shoreline development on Paugh Lake would have little effect on water quality conditions.

Paugh Lake

Location: Renfrew County
Burns Township

Watershed: Bonnechere River

Morphometry Hydrology

Surface Area	712.3 hectares (1760 acres)
Mean Depth	14.1 metres (46.3 feet)
Max. Depth	51.8 metres (170 feet)
Volume	100 x $10^6 m^3$ (81,070 acre-feet)
Watershed Area	75.1 km^2 (29 square miles)
Flushing Rate	0.2 times per year

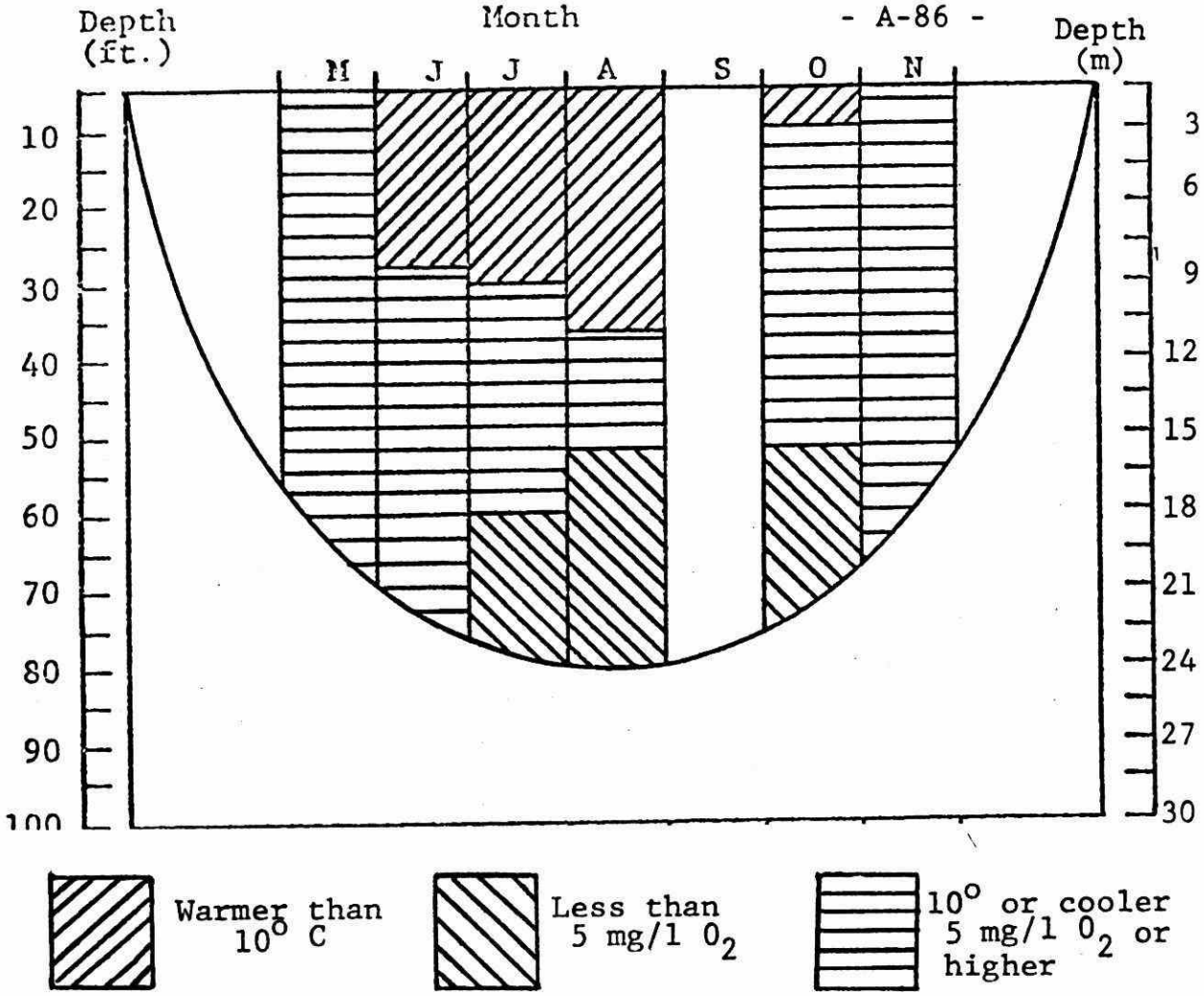
Shoreline Development

cottages, homes	77
vacant lots	29
tourist camps	1
tent, trailer sites	7
% shoreline crown	80
% shoreline patent	20

Estimated Phosphorus Supply (Annual)

Upstream lakes	98.2 kg	(216 lbs)	14%
Land runoff	201.4 kg	(443 lbs)	29%
Atmosphere	356.8 kg	(785 lbs)	50%
Shoreline Development	52.3 kg	(115 lbs)	7%
Sensitivity Index	7		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.6	18.4	1.0	10	13	36	10	218	0.09	6.3-7.3


Depth (ft.)
Month
M J J A S O N
Depth (m)
10 20 30 40 50 60 70 80 90 100
3 6 9 12 15 18 21 24 27 30
Warmer than 10° C
Less than 5 mg/l O_2
10° or cooler 5 mg/l O_2 or higher

Purdy Lake

The 1977 survey of Purdy Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Purdy Lake (illustrated above) indicate fair lake trout habitat. By late summer the usable lake trout habitat was confined to approximately 4.6 metres (15 feet) of the water column.

Purdy Lake supports an existing cottage density of one unit for each 4.7 hectares (11.7 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 4.2 hectares (10.3 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Similarly owing to the lake's shallow nature and relatively small volume of bottom water, its oxygen resource is considered to be highly susceptible to further depletion.

It is concluded that further shoreline development on Purdy Lake could cause a significant increase in algal production and depletion of the lake's oxygen resource.

Purdy Lake

Location: Hastings County
Bangor, Wicklow and McClure

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	132.7 hectares (328 acres)
Mean Depth	9.0 metres (29.5 feet)
Max. Depth	23.8 metres (78 feet)
Volume	12.0 x $10^6 m^3$ (9,700 acre-feet)
Watershed Area	12.5 km^2 (4.8 square miles)
Flushing Rate	0.3 times per year

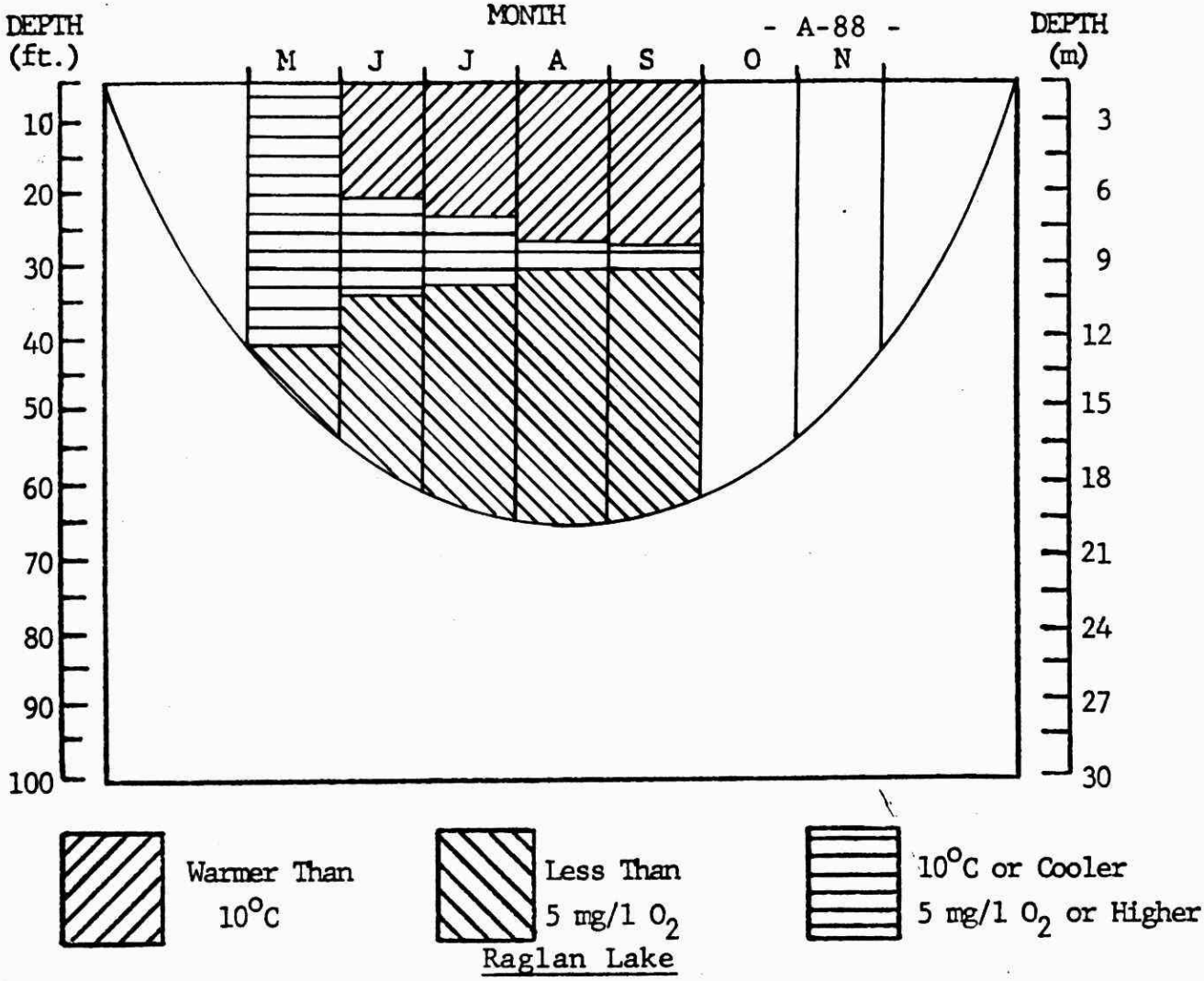
Shoreline Development

cottages, homes	28
vacant lots	4
tourist camps	3
tent, trailer sites	84
% shoreline crown	23
% shoreline patent	77

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil	
Land runoff	109.8 kg (242 lbs)	47%
Atmosphere	66.4 kg (146 lbs)	29%
Shoreline Development	55.0 kg (121 lbs)	24%
Sensitivity Index	852	

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.9	22.6	0.7	12	11	41	7	215	0.09	6.8-8.2



Raglan Lake

The 1978 survey of Raglan Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresonding high degree of water clarity. The temperature and oxygen profiles (illustrated above) indicate poor trout habitat with only 2.0 metres (6.6 feet) of suitable water remaining in September.

Raglan Lake supports an existing cottage density of one unit per 4.7 hectares (11.6 acres) of lake surface area. Development of the registered vacant lots would increase this density to 3.3 hectares (8.0 acres) of lake surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Similarly because of the lake's shallow maximum depth and small deep water volume, its oxygen resource is considered highly susceptible to depletion.

It is concluded that further shoreline development on Raglan Lake would have an adverse affect on surface water quality and further cause a significant depletion of the oxygen resource.

Raglan Lake

Location: Renfrew County
Raglan Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	137 hectares (338 acres)
Mean Depth	9.2 metres (30.2 feet)
Max. Depth	20.1 metres (65.9 feet)
Volume	12.6 x $10^6 m^3$ (10,215 acre-feet)
Watershed Area	9.4 km^2 (3.6 square miles)
Flushing Rate	0.2 times per year

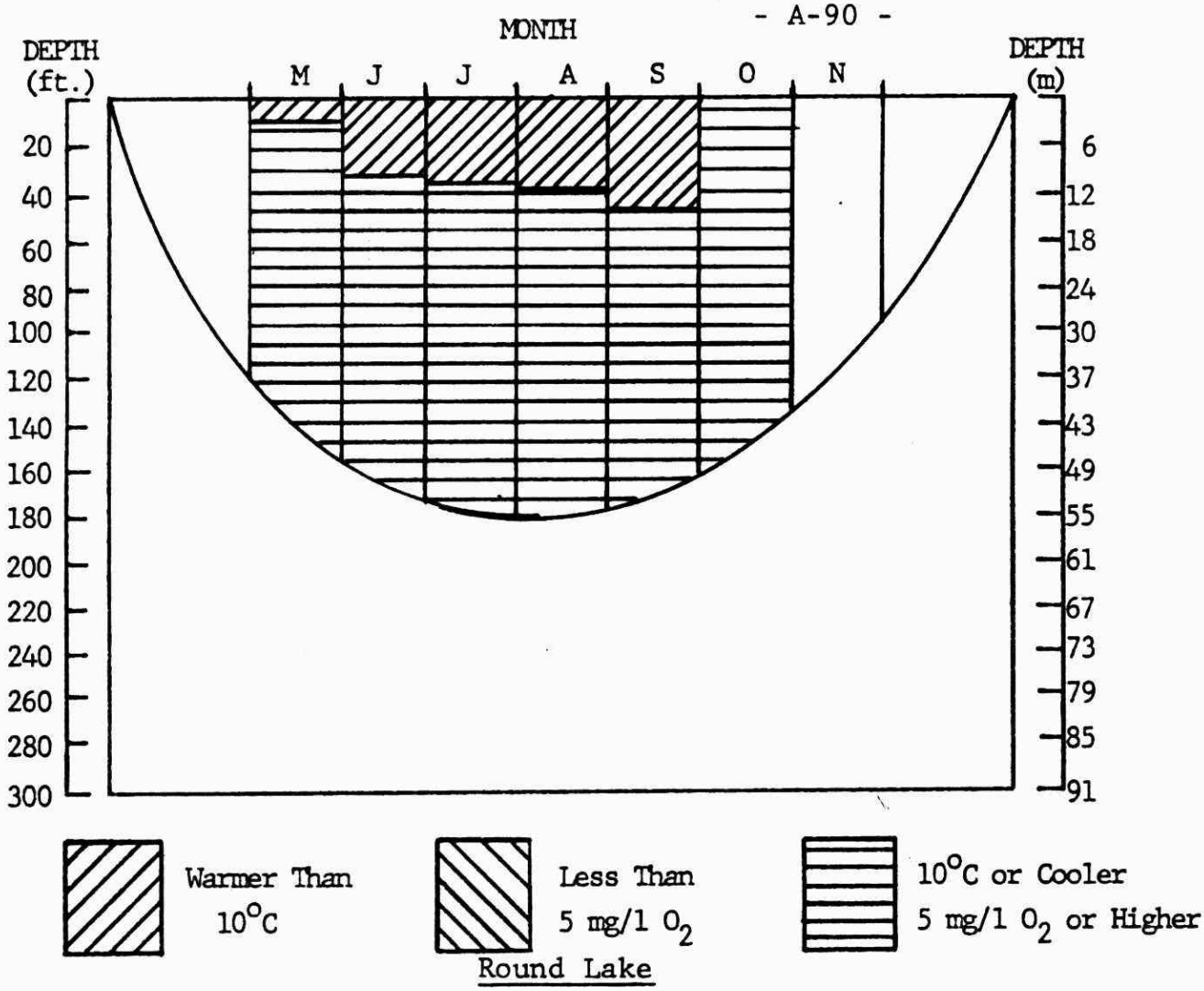
Shoreline Development

cottages, homes	27, 2
vacant lots	13
tourist camps	0
tent, trailer sites	0
% shoreline crown	information not available
% shoreline patent	information not available

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil	
Land runoff	44.4 kg (97.7 lbs)	26%
Atmosphere	102.8 kg (226.2 lbs)	61%
Shoreline Development	22.7 kg (49.9 lbs)	13%
Sensitivity Index	88	

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.2	20.2	2.1	6	94	120	11	310	.08	7.9-8.2



Round Lake

The 1978 survey of Round Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles of Round Lake (illustrated above) indicate excellent lake trout habitat. The lake's entire water column contained suitable oxygen conditions for lake trout.

Round Lake supports an existing cottage density of one unit per 8.9 hectares (22.1 acres). Development of the registered vacant lots would increase this density to 7.2 hectares (17.7 acres) of lake surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be low. Similarly because of the lake's large depth and volume of bottom water its oxygen resource is considered to have a low susceptibility to depletion.

It is concluded that further shoreline development on Round Lake would have little affect on water quality conditions.

Round Lake

Location: Renfrew County
Richards and Hagarty Townships

Watershed: Bonnechere River

Morphometry Hydrology

Surface Area	3074 hectares (7,596 acres)
Mean Depth	13.2 metres (43.2 feet)
Max. Depth	54.9 metres (180 feet)
Volume	404.6 x $10^6 m^3$ (328,949 acre-feet)
Watershed Area	989 km^2 (382 square miles)
Flushing Rate	0.8 times per year

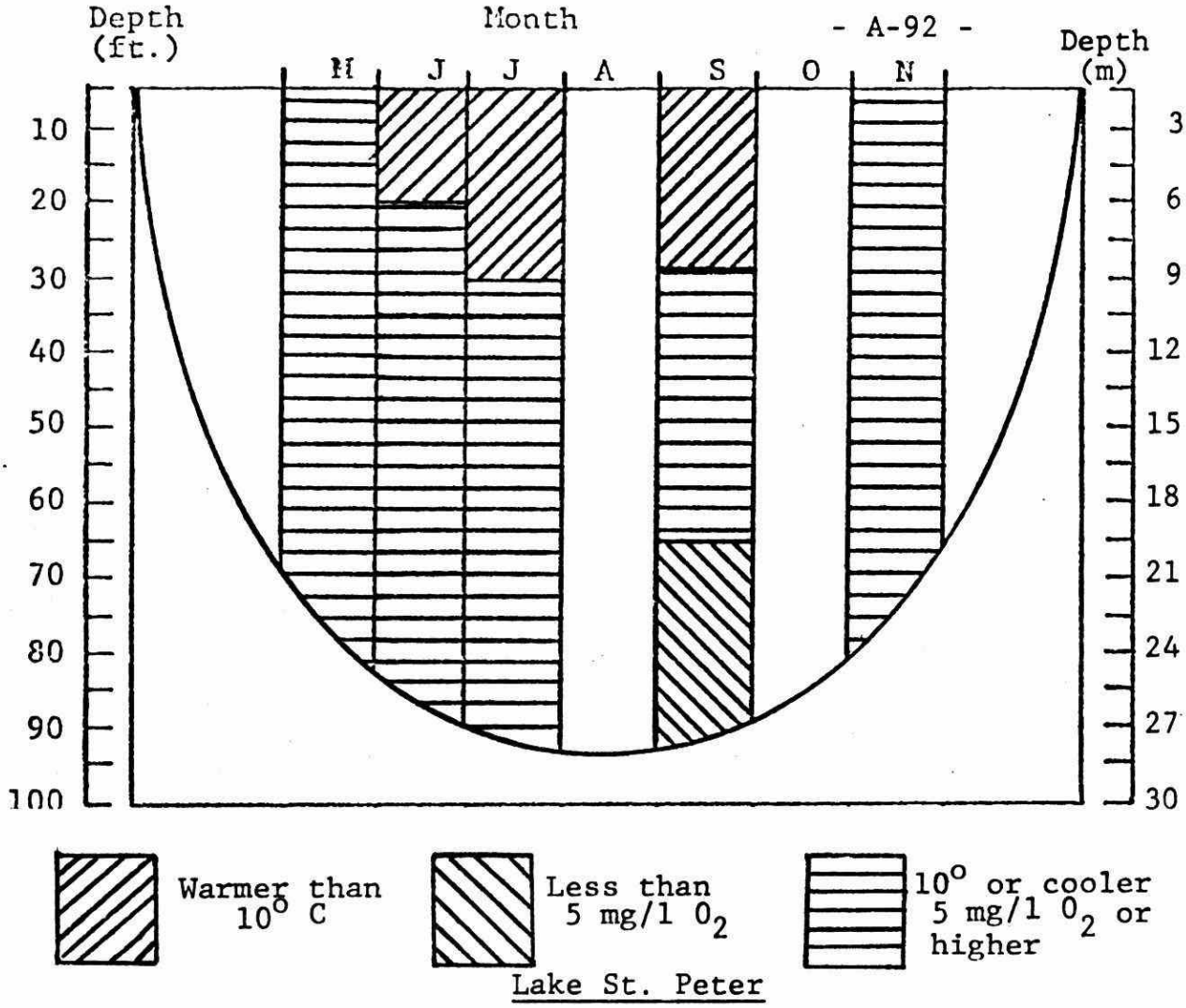
Shoreline Development

cottages, homes	274, 70
vacant lots	85
tourist camps	7
tent, trailer sites	506
% shoreline crown	10
% shoreline patent	90

Estimated Phosphorus Supply (Annual)

Upstream lakes	1700 kg	(3740 lbs)	20%
Land runoff	3927 kg	(8639 lbs)	46%
Atmosphere	2306 kg	(5073 lbs)	27%
Shoreline Development	593 kg	(1305 lbs)	7%
Sensitivity Index	0.5		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
4.6	15.1	1.7	16	18	43	7	280	0.15	6.7-7.5



Lake St. Peter

The 1976, 1977 and 1978 surveys of Lake St. Peter revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The 1976 temperature and oxygen profiles of Lake St. Peter (illustrated above) indicate good lake trout habitat. Approximately 10.7 metres (35 feet) of the lake's water column contains suitable oxygen conditions for trout at the end of the summer. The 1977 and 1978 profiles (not illustrated) are similar to those shown above.

The shoreline of Lake St. Peter supports an existing cottage density of one unit for each 1.3 hectares (3.2 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 1.1 hectares (2.7 acres) of lake surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is low. While the lake is shallow, its flushing rate appears to have a modifying influence on the degree of oxygen depletion which occurs. The oxygen resource is considered to be moderately susceptible to further depletion.

It is concluded that a moderate potential exists for further shoreline development on Lake St. Peter to cause increased algal production and depletion of the oxygen resource.

Lake St. Peter

Location: Hastings County
McClure Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	234.7 hectares (580 acres)
Mean Depth	7.6 metres (24.9 feet)
Max. Depth	28.6 metres (94 feet)
Volume	17.8 x $10^6 m^3$ (14,414 acre-feet)
Watershed Area	67.1 km^2 (25.9 square miles)
Flushing Rate	1.3 times per year

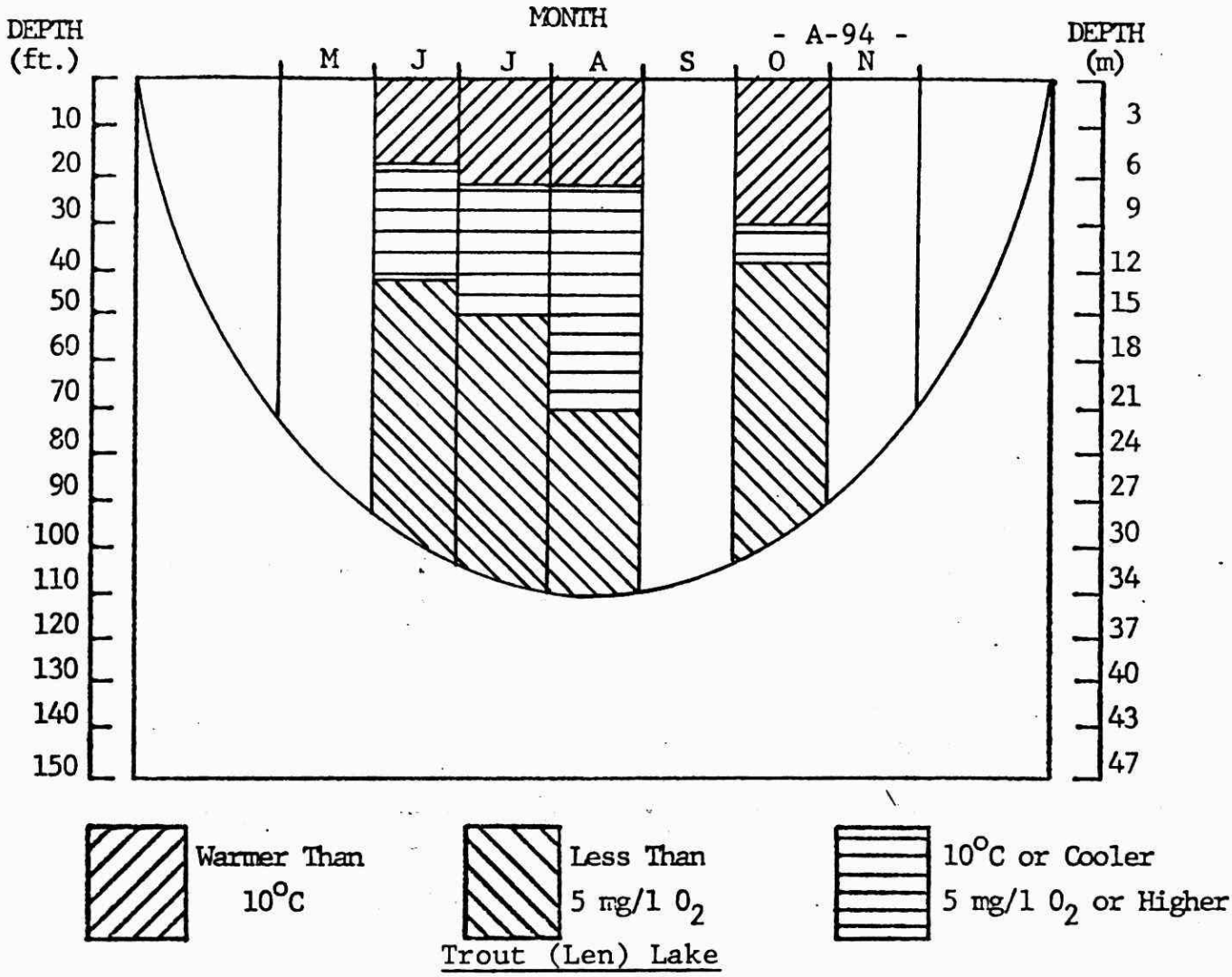
Shoreline Development

cottages, homes	182
vacant lots	32
tourist camps	10
tent, trailer sites	301
% shoreline crown	10
% shoreline patent	90

Estimated Phosphorus Supply (Annual)

Upstream lakes	20.9 kg	(46 lbs)	3%
Land runoff	311.8 kg	(686 lbs)	46%
Atmosphere	117.3 kg	(258 lbs)	17%
Shoreline Development	235.4 kg	(518 lbs)	34%
Sensitivity Index	22		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.1	16.7	1.1	15	12	34	13	269	0.20	6.4-7.7



Trout (Len) Lake

The 1978 survey of Trout (Len) Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles for Trout Lake (illustrated above) indicate poor lake trout habitat exists in October. In general, oxygen conditions are poorer than would be expected based on the lake's substantial mean depth. The June sampling results suggest the lake probably did not undergo complete mixing at the time of spring overturn. Some improvements in oxygen conditions were detected during July and August as a result of photosynthetic oxygen supply.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. The oxygen resource is under stress at present, therefore, the lake's susceptibility to further oxygen depletion is considered to be high.

It is concluded that further shoreline development on Trout Lake may be detrimental to both surface water quality and the deep water oxygen resource.

Trout (Len) Lake

Location: Lennox & Addington County
Ashby Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	158 hectares (390 acres)
Mean Depth	14.5 metres (47.5 feet)
Max. Depth	33.5 metres (109.9 feet)
Volume	22.8 x $10^6 m^3$ (18,524 acre-feet)
Watershed Area	22.3 km^2 (57.8 square miles)
Flushing Rate	0.4 times per year

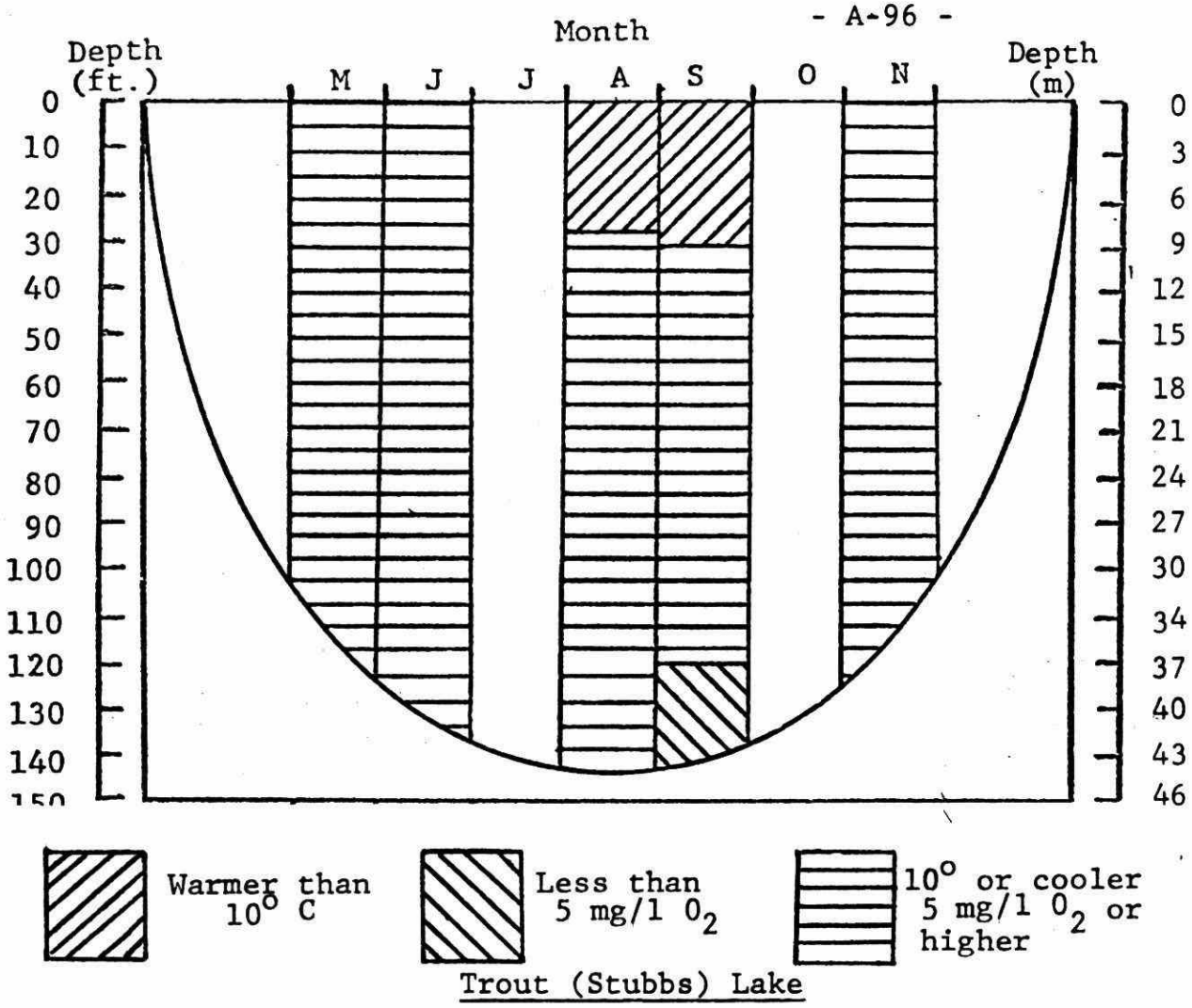
Shoreline Development

cottages, homes	9
vacant lots	1
tourist camps	1
tent, trailer sites	1
% shoreline crown	90
% shoreline patent	10

Estimated Phosphorus Supply (Annual)

Upstream lakes	26.4 kg	(58.1 lbs)	11%
Land runoff	81.0 kg	(178.2 lbs)	35%
Atmosphere	118.5 kg	(260.7 lbs)	51%
Shoreline Development	5.5 kg	(12.1 lbs)	2%
Sensitivity Index	56		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.4	17.7	1.3	8	61	86	11.4	299	0.10	7.9-8.0



Trout (Stubbs) Lake

The 1976 survey of Trout (Stubbs) Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and ocrresponding high degree of water clarity.

The temperature and oxygen profiles of Trout Lake (illustrated above) indicate excellent lake trout habitat. The lake's entire water column contains suitable oxygen conditions for lake trout.

Trout Lake supports an existing cottage density of one unit for each 1.7 hectares (4.2 acres) of lake surface area. Development of the registered vacant lots would increase the cottage density to one unit for each 1.2 hectares (2.9 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. Based on the lake's large depth and volume of bottom water, its oxygen resource is considered to have a low susceptibility to depletion.

It is concluded that the effect of further shoreline development on Trout Lake would be limited to a potential decline in water clarity which would not significantly reduce the recreational value of the lake.

Trout (Stubbs) Lake

Location: Renfrew County
Sherwood Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	137.2 hectares (339 acres)
Mean Depth	15.4 metres (50.5 feet)
Max. Depth	42.7 metres (140 feet)
Volume	21.2 x $10^6 m^3$ (17,162 acre-feet)
Watershed Area	41.2 km^2 (15.9 square miles)
Flushing Rate	0.68 times per year

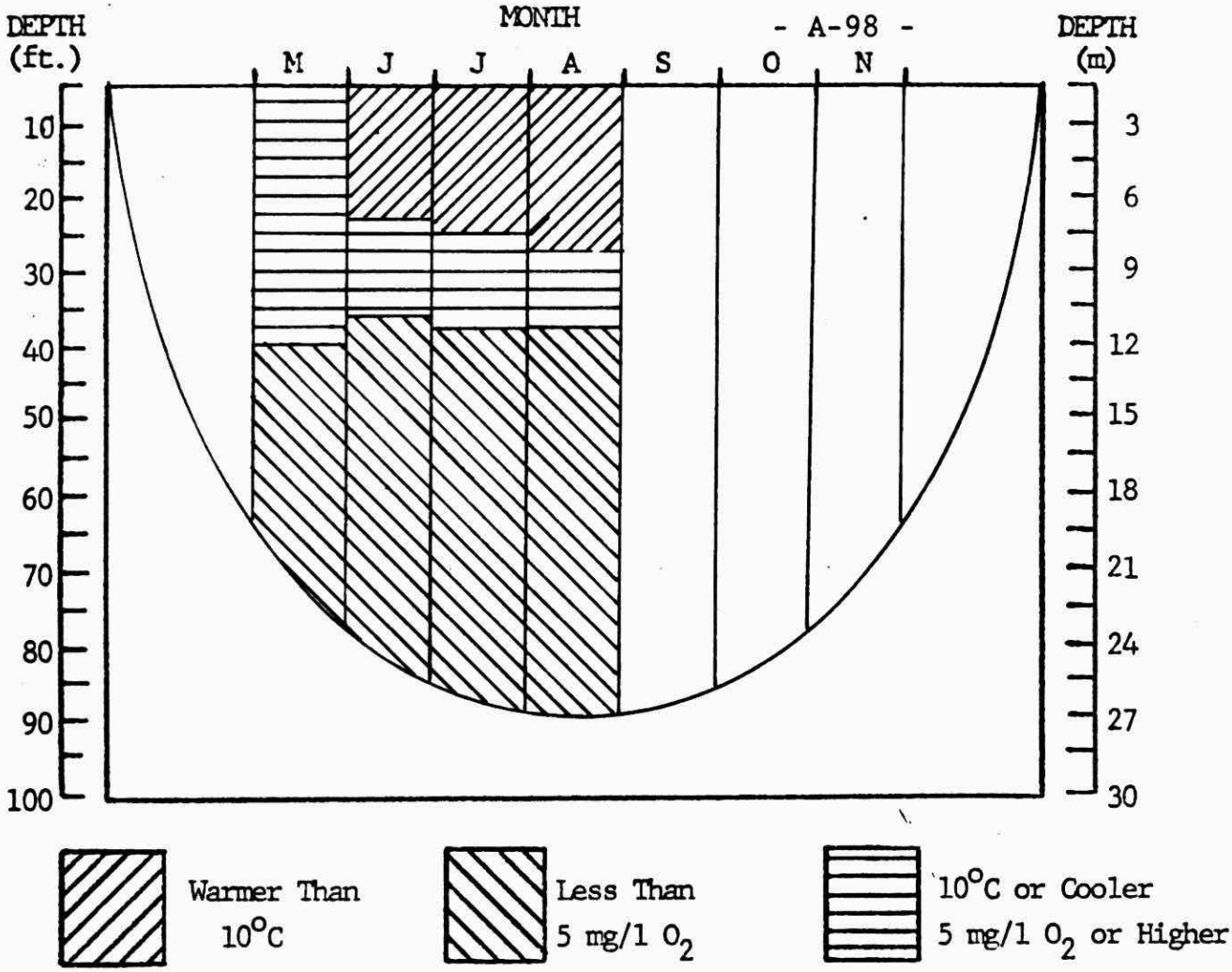
Shoreline Development

cottages, homes	81
vacant lots	35
tourist camps	2
tent, trailer sites	17
% shoreline crown	2
% shoreline patent	98

Estimated Phosphorus Supply (Annual)

Upstream lakes	77.3 kg	(170 lbs)	21%
Land runoff	135.4 kg	(298 lbs)	36%
Atmosphere	103.2 kg	(227 lbs)	27%
Shoreline Development	60.4 kg	(133 lbs)	16%
Sensitivity Index	46		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
6.1	20.0	1.4	7	15	40	7	245	0.08	6.5-6.8



Wabun Lake

The 1978 survey of Wabun Lake revealed excellent water quality for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and a corresponding high degree of water clarity.

The temperature and oxygen profiles (illustrated above) indicate poor habitat for lake trout. The lake did not mix at spring overturn below a depth of 12.0 metres (40 feet) in 1978 and therefore had a highly confined zone of usable lake trout habitat throughout the year.

Wabun Lake supports no development at present.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be high. Since Wabun Lake does not undergo spring overturn it is considered to have a high susceptibility to further oxygen depletion.

It is concluded that any shoreline development would have detrimental affects on both water quality and the oxygen resource.

Wabun Lake

Location: Renfrew County
Brougham Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	44 hectares (110 acres)
Mean Depth	13.3 metres (43.6 feet)
Max. Depth	27 metres (88 feet)
Volume	5.9 x $10^6 m^3$ (4,783 acre-feet) (
Watershed Area	2.6 km^2 (1.0 square miles)
Flushing Rate	0.1 times per year

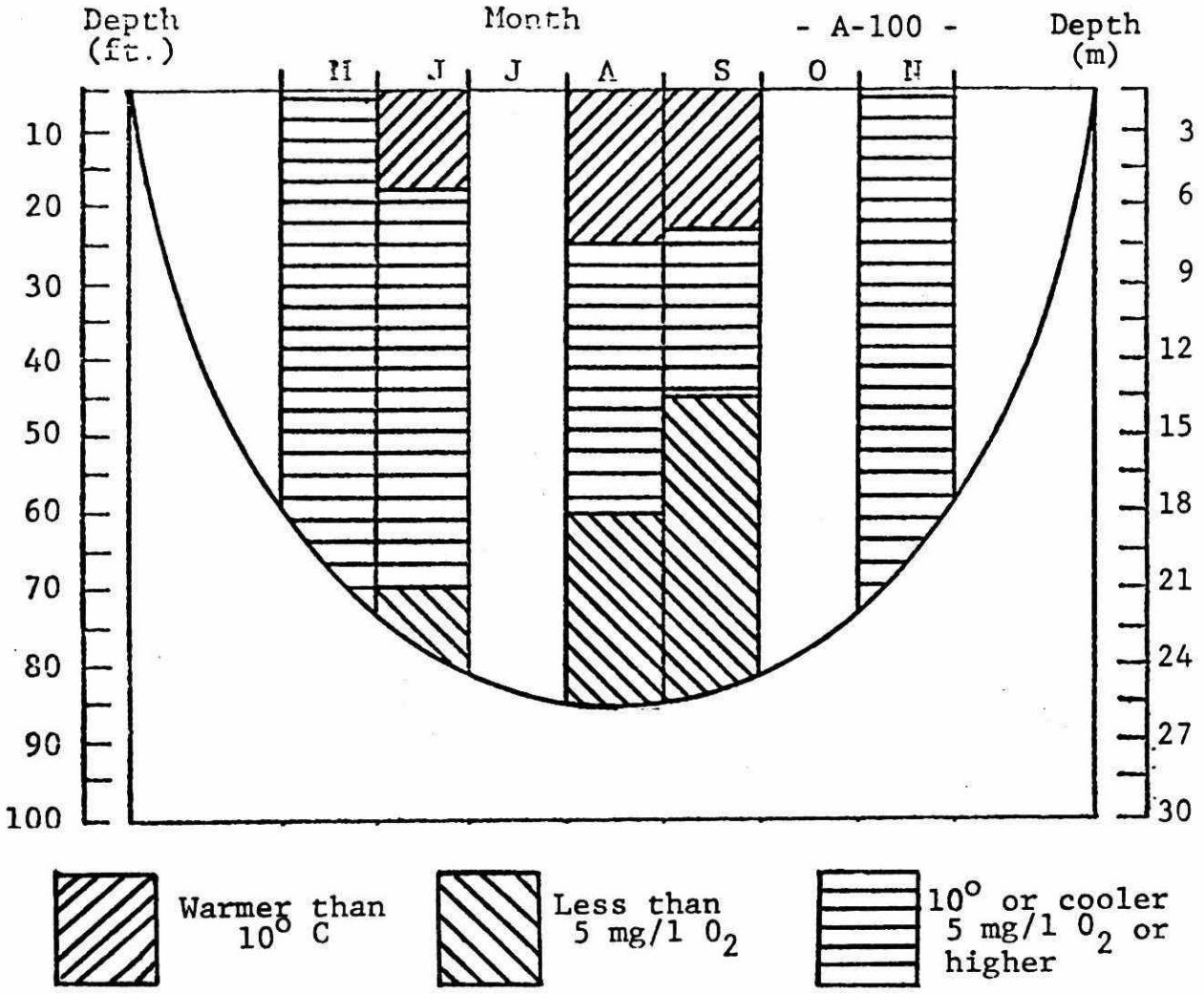
Shoreline Development

cottages, homes	0
vacant lots	0
tourist camps	0
tent, trailer sites	0
% shoreline crown	100
% shoreline patent	0

Estimated Phosphorus Supply (Annual)

Upstream lakes	Nil		
Land runoff	11.9 kg	(26.2 lbs)	26%
Atmosphere	33.8 kg	(74.4 lbs)	74%
Shoreline Development	Nil		
Sensitivity Index	460		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
7.0	22.9	1.4	5	63	87	10.2	322	0.15	7.8-7.9


Depth (ft.)
Month
- A-100 -
Depth (m)
M J J A S O N
10 20 30 40 50 60 70 80 90 100
3 6 9 12 15 18 21 24 27 30
Warmer than 10° C
Less than 5 mg/l O_2
10° or cooler 5 mg/l O_2 or higher

Wadsworth Lake

The 1976 survey of Wadsworth Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Wadsworth Lake (illustrated above) indicate reasonably good lake trout habitat. Approximately 6.1 metres (20 feet) of the lake's water column remains suitable for lake trout by September.

Wadsworth Lake supports an existing cottage density of one unit for each 2.2 hectares (5.5 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 1.8 hectares (4.5 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be moderate. While the lake is shallow, its flushing rate appears to have a modifying influence on the degree of oxygen depletion which occurs. The oxygen resource of the lake is considered to be moderately susceptible to depletion.

It is concluded that a moderate potential exists for further shoreline development on Wadsworth Lake to cause increased algal production and further depletion of the oxygen resource.

Wadsworth Lake

Location: Renfrew County
Radcliffe Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	199.1 hectares (492 acres)
Mean Depth	7.2 metres (23.6 feet)
Max. Depth	26.2 metres (86 feet)
Volume	14.3 x $10^6 m^3$ (11,601 acre-feet)
Watershed Area	47.1 km^2 (18.2 square miles)
Flushing Rate	1.2 times per year

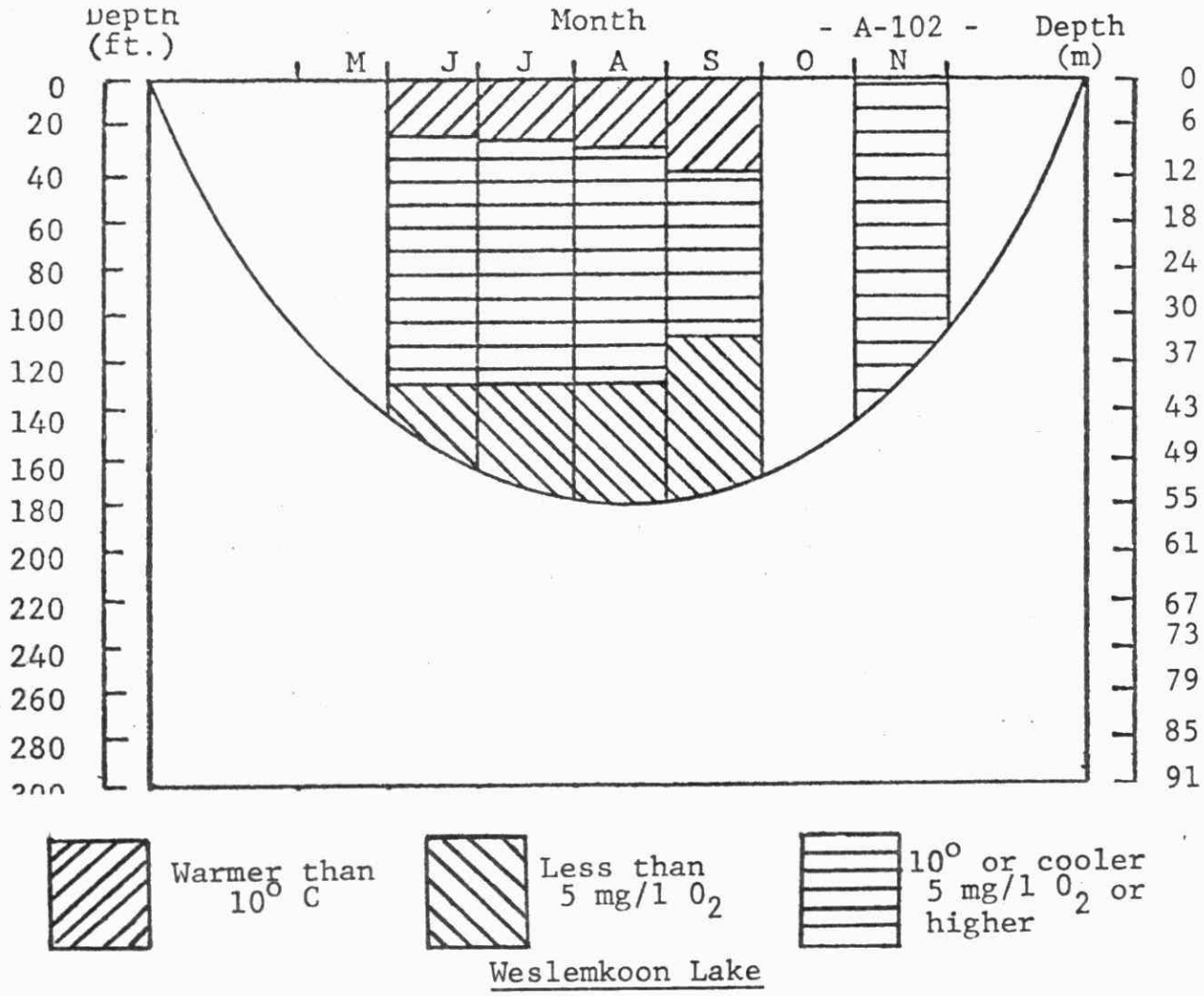
Shoreline Development

cottages, homes	89
vacant lots	18
tourist camps	1
tent, trailer sites	3
% shoreline crown	90
% shoreline patent	10

Estimated Phosphorus Supply (Annual)

Upstream lakes	37.7 kg	(83 lbs)	9%
Land runoff	170.4 kg	(375 lbs)	40%
Atmosphere	154.5 kg	(340 lbs)	36%
Shoreline Development	61.8 kg	(136 lbs)	15%
Sensitivity Index	30		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
4.2	13.8	2.0	13	33	57	8	323	0.30	7.0-7.3



Weslemkoon Lake

The 1976 survey of Weslemkoon Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Weslemkoon Lake (illustrated above) indicate excellent lake trout habitat. Approximately 24.4 metres (80 feet) of the lake's water column contained suitable oxygen conditions for lake trout throughout the season.

Weslemkoon Lake supports an existing cottage density of one unit for each 5.4 hectares (13.3 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 5.1 hectares (12.5 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be low. While the lake's mean depth is moderately low, extensive areas of shallow water surround the deep lake trout waters. The portion of the lake which supports lake trout is deep and contains a large volume of bottom water which is considered to have a low susceptibility to further oxygen depletion.

It is concluded that further shoreline development on Weslemkoon Lake would have little effect on water quality conditions.

Weslemkoon Lake

Location: Lennox and Addington County
Ashby Township

Watershed: Madawaska River

Morphometry Hydrology

Surface Area	1955.9 hectares (4833 acres)
Mean Depth	9.3 metres (30.5 feet)
Max. Depth	54.9 metres (180 feet)
Volume	182.1 x $10^6 m^3$ (147,621 acre-feet)
Watershed Area	121.0 km^2 (46.7 square miles)
Flushing Rate	0.4 times per year

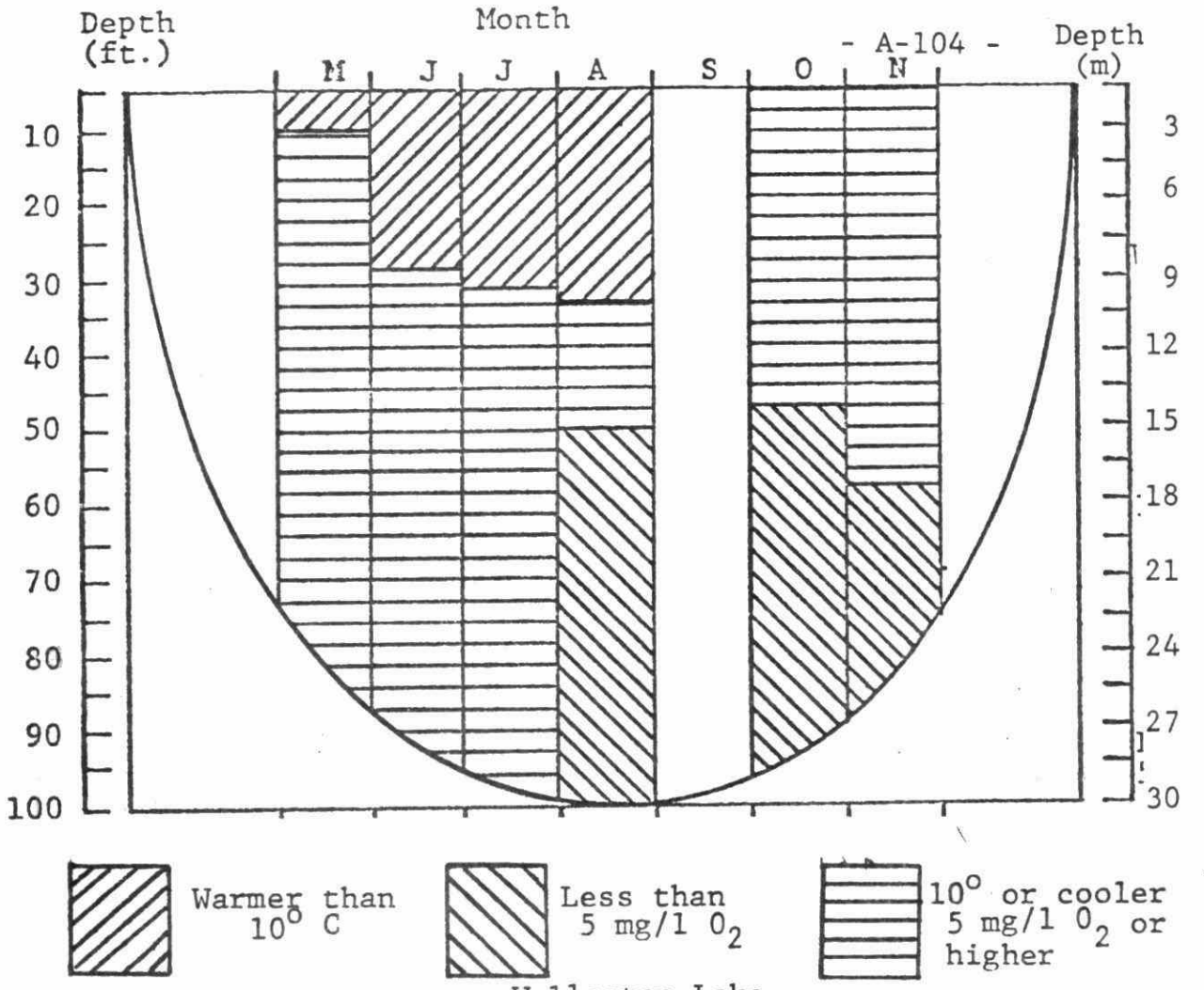
Shoreline Development

cottages, homes	363
vacant lots	19
tourist camps	5
tent, trailer sites	20
% shoreline crown	75
% shoreline patent	25

Estimated Phosphorus Supply (Annual)

Upstream lakes	317.7 kg (699 lbs)	13%
Land runoff	398.6 kg (877 lbs)	16%
Atmosphere	1470.0 kg (3234 lbs)	59%
Shoreline Development	290.0 kg (638 lbs)	12%
Sensitivity Index	2	

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.3	17.4	1.4	12	10	33	11	345	0.15	6.2-6.7



Wollaston Lake

The 1977 survey of Wollaston Lake revealed excellent water quality conditions for recreational usage. Seasonal average chlorophyll and Secchi disc visibility measurements indicated a low level of biological productivity (i.e. algae) and corresponding high degree of water clarity.

The temperature and oxygen profiles of Wollaston Lake (illustrated above) indicate fair lake trout habitat. By late summer, the lake's usable trout habitat appears confined to approximately 4.6 metres (15 feet) of the lake's water column.

Wollaston Lake supports an existing cottage density of one unit for each 1.8 hectares (4.4 acres) of lake surface area. Development of the registered vacant lots would increase the density to one unit for each 1.4 hectares (3.4 acres) of surface area.

Based on the information provided in Table 1, the potential of further shoreline development affecting the lake's surface water quality (i.e. increased algal densities, decreased water clarity) is considered to be low. Because of the lake's moderate depth and flushing rate its oxygen resource is considered to have a correspondingly moderate susceptibility to further depletion.

It is concluded that further shoreline development on Wollaston Lake would not cause a significant increase in algal production and should therefore not result in significant further oxygen depletion.

Wollaston Lake

Location: Hastings County
Wollaston Township

Watershed: Crowe River

Morphometry Hydrology

Surface Area	368.3 hectares (910 acres)
Mean Depth	9.4 metres (30.8 feet)
Max. Depth	32.0 metres (105 feet)
Volume	34.7 x $10^6 m^3$ (28,110 acre-feet)
Watershed Area	124.3 km^2 (48 square miles)
Flushing Rate	1.2 times per year

Shoreline Development

cottages, homes	205
vacant lots	65
tourist camps	2
tent, trailer sites	197
% shoreline crown	12
% shoreline patent	88

Estimated Phosphorus Supply (Annual)

Upstream lakes	45.9 kg	(101 lbs)	4%
Land runoff	581.8 kg	(1280 lbs)	54%
Atmosphere	184.5 kg	(406 lbs)	17%
Shoreline Development	270.4 kg	(595 lbs)	25%
Sensitivity Index	10		

Secchi m	Secchi ft.	Chl ug/l	Colour hazen	Alk mg/l	TDS mg/l	Total P ug/l	Total N ug/l	Iron ug/l	pH Range
5.1	16.7	1.2	12	67	108	11	360	0.05	6.8-7.9

APPENDIX B
LAKE SENSITIVITY INDEX BASED ON THE DILLON-RIGLER MODEL

It is a widely accepted view that phosphorus is the most important element controlling algal biomass in most lakes. Dillon & Rigler (1975) developed and refined a mathematical model for predicting phosphorus concentrations in lakes based on phosphorus inputs, lake morphometry and flushing rates. The same authors extended this model to predict the average summer chlorophyll concentration from either predicted or measured lake phosphorus concentration. Chlorophyll is a widely used and simple estimator of the phytoplankton standing crop. The phosphorus-chlorophyll relationship provides a means for estimating the expected change in algal biomass level that will result from a change in phosphorus input. Additional shoreline cottage or permanent home development is often the principal cause of increased phosphorus supply to our inland recreational lakes. The model is extremely useful from a resource management standpoint for assessing and responding to new development proposals. Management personnel can predict the response of a lake for any specific development proposal. Moreover, with some slight modifications, the model can be used to rank lakes by their sensitivity to phosphorus in terms of chlorophyll production. This extends the usefulness of the model by allowing it to be used as a tool in the planning process, as well as responding to specific shoreline development proposals.

Reduced to its simplest form, the Dillon & Rigler's formula for predicting the phosphorus concentration in lake water is:

$$P = \frac{1 - R}{Q} \times J_T \qquad (1)$$

where $[P]$ is the phosphorus concentration

J_T is the total phosphorus supply, both natural and anthropogenic,

Q is the total volume of water discharged per year

R is the phosphorus retention coefficient which is functionally related to the sedimentation rate of phosphorus

The relationship between $[P]$, the lake phosphorus concentration and the average summer chlorophyll concentration is described by:

$$\log [\text{chlorophyll}] = 1.45 \log [P] - 1.14 \qquad (2)$$

The slope of the log-log regression line is greater than 1 indicating that chlorophyll concentration (or algal biomass) increases at a faster rate than does the phosphorus concentration.

By combining equations 1 and 2, chlorophyll concentration may be expressed as a power function of phosphorus supply:

$$[\text{chlorophyll}] = \frac{\left(\frac{1 - R}{Q}\right)^{1.45}}{13.80} \times J_T^{1.45} \qquad (3)$$

In terms of long-term average conditions, the natural phosphorus supply, the lake sedimentation rate and the annual discharge volume may be considered constant for any specific lake. The only variable parameter in the above equation is the total phosphorus supply due to anthropogenic variability in the artificial phosphorus supply. The average chlorophyll concentration of a lake is related to the phosphorus supply by a hydrologic constant expressed as:

$$\frac{\left(\frac{1 - R}{Q}\right)^{1.45}}{13.80}$$

By the appropriate estimation of the lake phosphorus supply and certain hydrologic characteristics, equation (3) can be used to predict a lake's chlorophyll concentration.

The equation may be simplified to:

$$[\text{chlorophyll}] = kJ_T^{1.45}$$

where k is a hydrologic constant expressed as:

$$\frac{\left(\frac{1 - R}{Q}\right)^{1.45}}{13.80}$$

The hydrologic constant may be viewed as a sensitivity index. The magnitude of the index is a measure of a lake's inherent sensitivity to a change in trophic status as a result of a change in phosphorus supply. Lakes with a large index value (high sensitivity) will undergo a greater change in chlorophyll levels with an incremental increase in annual phosphorus supply than will lakes with a small index value (low sensitivity). The sensitivities of the 52 lakes in this report have been calculated and are summarized in descending order in Table 1.

Working examples of the application of the sensitivity index to estimate chlorophyll concentration are provided below for both a relatively insensitive lake, Paugh Lake in Burns Township, and a relatively sensitive lake, Little Clear Lake in Bedford Township.

Little Clear Lake:

Estimated phosphorus supply at present: J_T = 57.37 kg/yr
Sensitivity index: S chl = 343×10^{-5}

Predicted chlorophyll concentration under present conditions:

$$\overline{chl} = (343 \times 10^{-5}) \times (57.37)^{1.45} = 1.2 \text{ ug/l}$$

Measured chlorophyll concentration = 1.3 ug/l
Predicted chlorophyll concentration for a 100 kg/yr increase in phosphorus supply:

$$chl = (343 \times 10^{-5}) \times (157.37)^{1.45} = 5.2 \text{ ug/l}$$

Paugh Lake

Estimated phosphorus supply at present: J_T = 707.45 kg/yr
Sensitivity index: S chl = 7.13×10^{-5}
Predicted chlorophyll concentration under present conditions:

$$\overline{chl} = (7.13 \times 10^{-5}) \times (707.45)^{1.45} = 1.0 \text{ ug/l}$$

Measured chlorophyll concentration = 1.0 ug/l
Predicted chlorophyll concentration for a 100 kg/yr increase in phosphorus supply:

$$chl = (7.13 \times 10^{-5}) \times (807.45)^{1.45} = 1.2$$

The above examples illustrate that Little Clear Lake is very much more sensitive to addition of phosphorus than Paugh Lake. An increase in the phosphorus supply of only 100 kg/yr to Little Clear Lake would be expected to produce approximately a four fold increase in the mean summer chlorophyll concentration. An increase in the phosphorus supply of 100 kg/yr for Paugh Lake creates less than a one fifth increase in its chlorophyll concentration. Paugh Lake is therefore less sensitive to nutrient enrichment than is Little Clear Lake.

APPENDIX C
SOIL TESTS FOR PHOSPHORUS RETENTION CAPABILITY

Soil tests conducted by the Southeastern Region on a portion of the Precambrian Sheild north of Kingston in 1974, 1975 and 1976 provide technical support for the recommendations made in this report. Additional details are available in published Southeastern Region reports (5,6). In all, 255 soil tests were conducted in 80 borrow pits and 17 developments. As a result of this program the following conclusions are made.

1) Within the area tested, the soil mantle generally has a good phosphate retention capability but it is limited by the amount of soil present.

2) Present material being used for raised tile beds comes from major sand/gravel pits and is too coarse. It has a poor phosphate retention capability.

3) Suitable material is available at most major deposit sites. Generally, it is the top two to three feet of material which constitutes and A and B horizons and is characteristically light brown in colour.

The reports (references 5,6) recommend:

1) that only the materials having a good phosphate retention capability be used in raised tile beds for septic tank systems on lakes judged to be sensitive to nutrient input;

2) that a 100 foot setback for raised tile beds be maintained on all sensitive lakes in the Southeastern Region. This recommendation is based on the average soil depth

and phosphate retention capability of the native granular soils between tile beds and the lakes;

3) that Health Unit and pit operators be advised of the location of suitable material and how it can be recognized.